Annual Subscription Price, $3. 89 ***Published Ten Times a Year.***

The works of the Lord are great, sought out of all them that have pleasure therein.—Ps. cxi, 2.

THE SIDEREAL MESSENGER.

NOVEMBER, 1890.

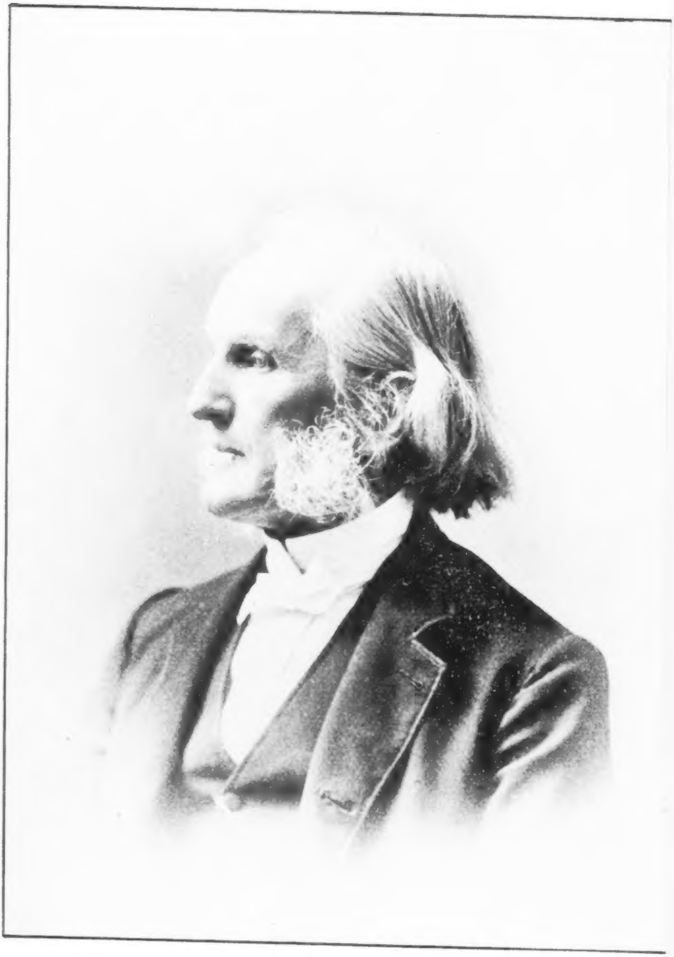
CONTENTS.

WM. W. PAYNE, EDITOR,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NORTHFIELD, MINN.

Entered at the Post Office at Northfield, Minn., for transmission through the mail at second class rates.



CHESTER SMITH LYMAN.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, NO. 9. NOVEMBER, 1890. WHOLE NO. 89

THREE INTERESTING BINARIES.

NEWTON M. MANN.

For THE MESSENGER.

Some years ago I presented in the MESSENGER a discussion of the star 61 Cygni which attracted a little attention, and is mentioned for all it is worth in Miss Clerke's book on the Progress of Astronomy in the Nineteenth Century. The leisure to review that labor with the aid of later observations having come to me, I have given the subject as thorough a study as I know how, the result of which, together with some work on two other stars, I am glad to place on record in these same columns.

The curve described by the companion of 61 Cygni is one through which no end of different ellipses may be made to pass with nearly equal satisfaction. Which of these is nearest to the true orbit must be determined by other considerations. The first question is as to the probability of the star having passed its periastion during the time it has been under observation. This is a point I did not sufficiently consider in my first work. The considerable distance of this star and its increasingly slow motion indicate that it has been moving for the last hundred years toward the remotest part of its orbit, and that the apparent ellipse should be drawn with its center between the curve already described and the principal star. Such an ellipse may be drawn as shown on the following page (Fig. 1), angles and distances as in my former work. This I drew large with an excellent ellipsograph and worked out with care.* A comparison

* The elements obtained may be added merely as matter of curiosity.

ε	0.144	γ	57° 15′
π	294° 40	Ω	157° 15′
P	612.7 years.	T	2169.63

It is needless to say that the drawings in this article are only for purpose of illustration.

with the long list of observations gives nothing to complain of. One thing only leads me to suspect that it is not the orbit nor anything like it. These objects are not likely to show so small an eccentricity—0.144. Other efforts were then made—a score or more—all widely different, but preserving substantially the same curve required by the observations. It is hard to choose, but that which on the whole seemed to me to stand the best chance, is given in miniature

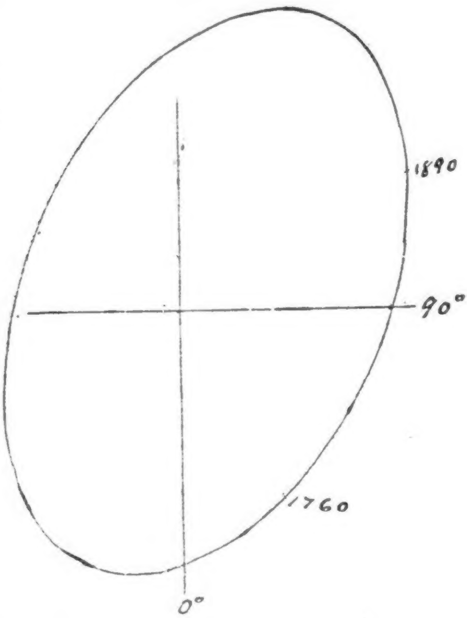


FIG. 1.

in Fig. 2. This, it will be observed from the position of the principal star, is a sufficiently eccentric orbit. It provides for a yet long-continued slow motion while reducing the period much below what has been heretofore calculated. These are the elements:

ε	0.529	γ	62° 17′
☊	170°	π	303°
P	462 years.	T	1661.42

α 23″.90

From what has been said it will be seen that this, or any other determination, can be only tentative; but after a good deal of labor I submit the following as perhaps the best that can be done at present. On this basis, taking the parallax at 0.″55, the mass of the system is 1.45 times that of the sun.*

We pass now to a more brilliant and otherwise hardly less interesting object. Castor has pretty effectually set aside

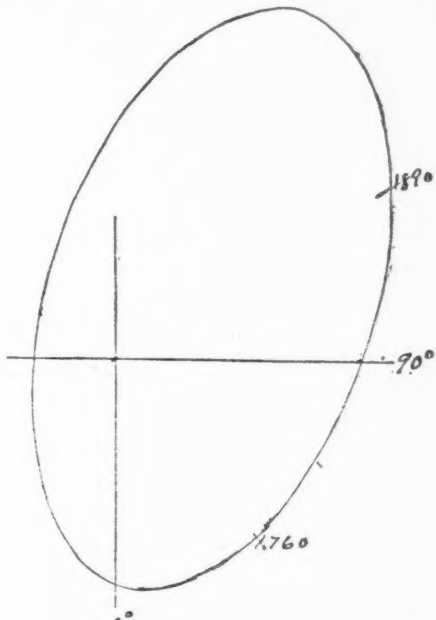


Fig. 2.—61 Cygni.

the orbit that Wilson gave it in 1877, the delineation of which in the "Handbook of Double-Stars" has afforded many of us amateurs so much delight. Recent observations make it almost certain that he and others erred in this case,

* I was once disposed to think that the relative mass of the components of a binary system might be indicated by systematic discrepancies between measures of distances at different epochs and the distance computed from augular displacement. It is a delusion.

as I did years ago with 61 Cygni, in supposing the periastron to lie within the curve described since observations commenced. In fact the two stars present a remarkably similar situation, both having shown for a long time an increasingly slow motion, indicating in both an approach to the point of greatest distance. In the case of Castor that point is now very surely passed, the observations of the last

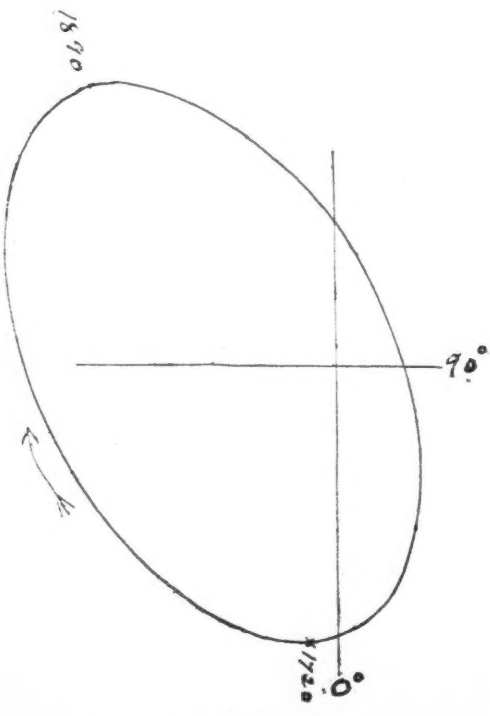


FIG. 3.—CASTOR.

two years showing a sensible decrease of distance. This is a state of things not provided for in Wilson's orbit until after the year 2147, and it is just the clew needed for something like a definite determination of the elements of this gorgeous system.

Two points now apparent about Castor ought to have

been considered probable before—first, that the companion has been seen only in the remoter part of its orbit, and second, that the orbit is of high eccentricity, this latter on general grounds. When we recall that the parallax of this star is almost, or quite, inappreciable, the enormous distance represented by five seconds of arc ought, it would seem, to have suggested anything but a periastron.* When in 1949 the real periastron is reached the two stars will be less than one second apart. I take pleasure in submitting a miniature representation of this orbit according to my last work. The reader will observe that the decrease of distance since 1886 makes it certain that this cannot be far wrong.

This gives elements as follows:

ε	0.653
γ	63°
π	90°
Ω	28° 40′
λ	75° 53′
P	265.7 years.
T	1949
α	5″.54

As much attention is likely to be drawn to this star in the next few years I give the starting points of my calculation. On the strength of the earliest observations, which are discordant, I assume the position angle in 1722.42 to have been 355°. As Herschel's measurement in 1783.63 made it 293°.6, and again in 1791.15 so much as 293°.5, I take the mean and put it (corrected to Eq. 1890) at 293°.5 in 1785.45. Then Herschel's observation, 1802.06, is accepted as exact, also South's in 1825.24, Dawes' in 1833.14, Smith's 1843.13, Bond's 1848.30, O. Struve's 1854.94, Main's 1862.31, Wilson and Seabrook's 1872.86, Dembowski's 1875.25, and one of 1889 from the unpublished work of a distinguished astronomer whose name I am not at liberty to give. The curve that runs through these points keeps well in the mean of all the observations, some 230 in number, that I have before me. The star will be slow for some time yet, and we shall hardly live to see how it accords with the calculation; but here are its places on toward the middle of the next century:

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* It is interesting to note that the earlier efforts to determine this orbit now appear the best. Compare Madler's elements, 1842, with the numerous attempts subsequently published, Handbook of Double-stars, pp. 239-240.

Date.	Position Angle.	Distance.
1898.70	225°	
1908.70	220°	5″.14
1917.52	215	
1924.90	210	4″.30
1930.70	205	
1935.05	200	3″.26
1938.27	195	
1940.64	190	2″.41
1942.39	185	
1943.71	180	1″.82

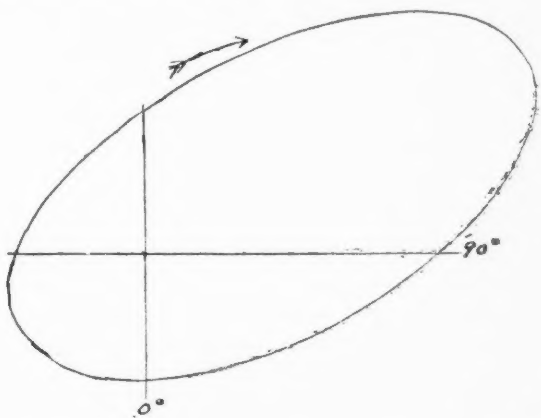
About ten years ago I read a paper on the orbit of 70 Ophiuchi before the Academy of Science in Rochester, N. Y. The elements I then obtained were:

T	1806.63
ω	178°
Ω	118° 36′
γ	55° 8′
ε	0.5085
α	4″.41
P	87.40 years.

Since then the star has passed through 90° of its orbit. I have been interested, therefore, in reviewing that work, which I have done in as thorough a manner as possible. This is a star that has just made an entire revolution since the first good observation was made. One would think therefore that it might be easy to reduce. But a closed orbit has difficulties of its own. It restricts the liberty of conjecture by which one leaps over many obstacles. It leaves no back alley into which to pitch a surplus of time or space. Corrections and re-adjustments become delicate and difficult. At least so I have found it, and I should be almost ashamed to say how long I have worked on this thing. But there are always shorter cuts to an end that one sees after he gets there. The story therefore can be made brief.

Herschel in 1802.25 found the angle of position (corrected to Eq. 1890) 335°.6. The pair showed the same angle in 1890.37, as nearly as I can judge from the rather incongruous observations at hand of recent date. This makes the period 88.12 years. With a fixed ratio of square millimeters to years we assume what must be the contents of the ellipse representing the apparent orbit. Its eccentricity then remains to be found, and the direction of its node by a series of comparisons and approximations requiring some patience. Finally the ellipsograph must be so set that it will

meet all three of these requirements by describing a medial line through the points representing the observations of a century and enclosing the fixed number of square millimeters equivalent to 88.12 years. Add to this that the line must not be heavier than a hair, and that the measurements must be made under a strong lens. Progressed so far, Herschel's observation of 1804.41 comes in somewhat to modify the calculation, as it seems to require a period of a little less than 88 years. Between the two the best seems to be to put it at 88.04 years. The motion of this star has been so rapid of late that the reckoning of time has to be carried to the third place of decimals. A rude little diagram gives but a poor idea of this beautiful object. The orbit differs from the two others I have discussed in having the line of nodes nearly coincident with the projection of the major axis, so that the principal star appears less distorted from the focus by the inclination of the orbit.



As will be seen by a comparison of results, my present work is only a refinement upon that performed ten years ago. Some further slight changes may be made necessary by the observations of the next ten years, but these elements, cannot be much in error:

a	4″.45	e	0.4994
☊	120° 48′	π	295° 44′
γ	57°	P	88.04 years.
T	1895.28		

This determination compared with the observations accords excellently well back to 1825, when the plus residues (observed, minus computed angle) begin to be slightly in excess. But the observations are few and the excess is not more than 1°, always leaving out of account Herschel's two first, which contradict each other. The first of these, 90°, 1779.76, is short 8°.4, and is probably an error of record for 98° or possibly 100°.

I append an ephemeris:

Date.	Position Angle. °	Distance. ″	Remarks.
1890.990	330	2.00	
1891.560	325	2.04	
1892.160	320	2.09	
1892.777	315	2.12	
1893.426	310	2.16	
1894.072	305	2.16	
1894.761	300	2.16	
1895.280	295.73	2.13	Periastron passage.
1896.609	285	2.10	
1897.697	275	1.91	
1898.652	265	1.78	
1899.482	255	1.69	
1900.237	245	1.62	
1900.941	235	1.58	
1901.350	229	1.57	Min. apparent distance.

TENERIFFE, ALTA VISTA, TEYDE.

D. W. EDGECOMB.

FOR THE MESSENGER.

Thirty-four years ago the first experiment with telescopes at a high altitude was made at Teneriffe by Piazzi Smyth far up on the lava-covered side of Teyde, and the account of his residence and successful observations above the clouds forms a part of every astronomical library. Since that time, until quite lately, the island has been almost as little visited by travelers as before, and it is still quite out of the line of American travel.

Within three or four years, however, it has been growing as an English watering place, and every winter brings an increasing number who seek to avoid the fogs and storms of England.

It was many years since I had read "An Astronomer's Experiment," but the pleasure it had given me was still fresh in my memory; and it was therefore, with far more than the

interest of the ordinary tourist, that on the morning of the fifth day from the English coast, from the deck of an Australian steamer, touching at the Canaries, I was able to trace, far ahead and high amid the clouds, the dim outline of Teneriffe. We *may* see the peak, said the captain, but as it is more than thirty miles away, nearly at the other end of the island, and generally either covered with clouds, or hidden by those that cover the intervening mountains, it is only occasionally seen as we approach from this side. I was fortunate enough, however, before the day was over to see its snowy cone capping the grand mountain mass of which the whole island consists, delicate in the distance, and only suggesting its great height by the angle which the direction of its summit forms with the surface of the sea.

Approaching the shore, under the swift march of the steamer, the interest increases almost from moment to moment, as the massive features of the island are revealed. Vast rocky masses, of mingled green, brown, red and yellow, rise in precipitous cliffs from the sea, mountain ridges with their crests indented and broken, with cone and battlement and pinnacle, standing in relief against the sky, while many a deep and shadowy gorge came down to the sea between them, passed us as we approached our landing place, the harbor of Santa Cruz, the capital of the Canaries. Hardly can it be called a harbor but an anchoring place, sheltered in part from the trade wind and the swell of the Atlantic, by the mountainous Eastern end of the island, along which, at a mile or so distant, we had been sailing. And under the lee of these mountains also, we have come to realize, almost suddenly, as it were, by the absence of the sea breeze, and the cessation of that caused by the motion of the steamer, that we were in another climate, for a tropical sun shone down upon deck as the ship swung to her anchor, and the white-washed houses of the town on shore before us glowed and glistened in the summer light.

Landing, or rather tumbling ashore, for it was a tumbling swell that still came in against the mole from the Atlantic, we found ourselves in the midst of men and women in tropical dress, children in tropical undress, donkeys with the most overgrown loads, other officials in bright uniform bearing equally overgrown loads—of importance,—baskets of oran-

ges, canary birds in cages, golden sunshine, and withal, an immense quantity of the Spanish language. Following, however, a little streamlet of English which proceeded from the mouth of the hotel guide, we passed through the streets, stopping only to gaze at the solemn, deliberate tread of three camels, further reminding us that we were geographically in Africa, and at the parallel of the great desert.

Our destination is the Grand Hotel at Orotava;—where is the place on this side the Atlantic without its English "Grand Hotel"?—under the shadow of the peak, and, say all, where the climate more than justifies the ancient titles given to the islands, the "Gardens of Hesperides," the "Isles of the Blessed." It is a ride of about twenty-five miles and certainly it would be difficult to imagine a more beautiful one. The road rises fifteen hundred feet above the sea, passes through a dreary town, Laguna, at that height, but afterwards along the northern side of the island presenting a series of the grandest views of a land sloping from cloud to sea. Everywhere by the roadside, the geranium grows in weedy profusion, covered with scarlet blossoms, while petunias, pinks, violets, mignonette, and all our familiar plants, greet us from out the little gardens; and all in blossom, the climate making contemporaries of them all. From among these the little birds of Canary greeted us with chirp and twitter, making a June day of the first of February. Most striking of all are the palm and orange trees, the "waving plumes" of the one and the golden fruit of the other recalling to mind the half forgotten descriptions of Humboldt and Smyth.

And always as we approach, the trade-wind clouds open and close, everchanging in height and depth and form and color, displaying and again concealing, on one side far off below, the ocean, and far above on the other, the form of their king, the high and mighty peak.

From one side finally, at an elevation above it of a thousand feet, we look down into the "Valley of Orotava." A grand amphitheater it is, with mountains on three sides and the sea on the other. What could have been the cause and what the manner of such a subsidence? For the slope along which we have been advancing extends not to the sea level, but along the sea front ends in precipitous cliffs a thousand

feet in height. A section of this elevated slope, six miles or more in width, has sunken, gradually or suddenly, at some time, until its front is level with the sea, while its opposite side is still the mountain ridge. The sides of the valley then present sections, in some places nearly two thousand feet in thickness, of the higher portions of the island. Looking across the broad chasm, the mountains on the opposite side are blue with distance; towns and small clusters of houses lie scattered over the valley, and a little beyond the opposite and highest corner rises high the snowy peak.

Smyth had much to say of the clouds, and describes a curious and furious battle between the forces of the opposing trades. It would be indeed impossible to give even the faintest idea of the pictures presented by these trade-wind clouds seen during a residence of a few weeks at the sea level in the valley. Generally the mountains are covered, and a broad canopy extends over the valley and a little way out to sea; but at morning and evening they often break, lift and are dissipated, revealing the crests, the slopes and gorges that form the sides of the vast amphitheater, together with the crowning peak, and exciting more and more admiration each day, at the grand scale on which the whole is built.

So gradual is the elevation of the broad inclined plain from the sea that as one looks up the valley it is difficult to believe that the culminating crest is from six to seven thousand feet high, or that the clouds that meet and rest against the cultivated fields half way up the easy slope, are as high as those overhead.

In the early morning and in the afternoon, the lower air is clear and tranquil and affords beautiful pictures of distant objects in the telescope. Natural features, the curves in the sides of the high bluffs along the sea-front or the great sectional walls over-looking the valley, the homes of the ancient Guanches, and the houses and villages far away on the mountain slopes are so well defined that they appear to be but at a small part of their real distance, and the power of the telescope seems doubled. But the hope thereby raised that the evenings will be found also good for telescopic vision is rudely shattered. To the naked eye indeed, the evenings when clear from clouds are glorious in the extreme.

The concave sky seems lowered and the stars are near and brilliant. The scene is made more beautiful by the fact that the heavens are equally dark and the stars equally bright to the very crest of the mountains that form the southern horizon. I have more than once placed the peak in the field of view and watched the occultation of stars at various points along the cone, and their emersions on the western side. Generally the disappearance was sudden, almost like a lunar occultation, but sometimes, probably when the rays encountered a warm breath from the mountains, they performed strange gymnastics for a short period before dodging behind the cone.

To northern eye on these clear nights the region Argo, extending to the south and east of Canis Major is most resplendent with stars, while Sirius, raised by twenty degrees above its position as we are accustomed to see it, and supported from below by that grand field of thickly clustering stars of Argo, seems more than ever worthy of its title of Leader of the starry host.

But how they all twinkle, and how suspiciously large they look for there are two opposing currents of air in motion over the valley, and these are of different temperatures, so that the rays are sadly demoralized when they reach the eye. What an image, therefore, one gets in the telescope! A grove of chimneys could not work more mischief; and after many experiments at different hours on the clearest nights, I abandoned the telescope in disgust. All this might have been known *a priori* from the conditions so well studied and described by Smyth, but who would have believed the result would have been so invariable?

Experiments on the peak itself are hardly practicable before the middle of June, for it is too near the line of perpetual snow, and too liable to savage storms, and as I could not well stay so long, I must content myself with a pilgrim's visit to Alta Vista, and the Crater. The height is twelve thousand two hundred feet, and as the work begins at the sea level, there is no discount or reduction to the climber, from the total elevation to be overcome. One can ride to Alta Vista and the way is probably no better, if no worse, than when Smyth's cavalcade passed over it. It requires the same good qualities in horse or mule

and the same patience and endurance in the rider now as it did then. No one will question a single foot of the reputed height that has made the journey.

Passing up the valley the marks and evidences of volcanic action abound on every hand. They appear in the parasitic cones or craters that form prominent features of the broad plain itself, in the confused lava rocks that cover the surface, and the exposed edges of lava sheets in the sides of the gorges or "barancos;" and most and grandest of all, when one passes out above the misty cloud into the upper sunshine and finds himself in the "Canadas," the pumice strewn floor of the great ancient crater, eight miles in diameter with its encircling mountain walls and from the center of which rises before him the enormous mass of the central peak and its crowning "white-lipped" cone. No observer of lunar scenery can help exclaiming, surely this is the moon. Masses of red lava protrude from the fine pumice floor in broken heaps, and although confusing at first, a little observation shows the arrangement of radiating lines from the central cone. But it is from the peak itself that the lunar likeness is most striking.

For as one approaches, his eyes are always turning towards the summit so clearly defined against the sky, and from this point it is easy to see the continually recurring puffs of white vapor which are forced above the apparently sharp pointed top of the still active volcano.

Without the corrective of an actual knowledge of the angle it is easy to over-estimate the degree of inclination of a mountain like the cone of Teyde. It is about thirty degrees, but seems nearer forty, as the sure-footed mule of the islands zig-zags up the cindery side. The path lies between two enormous streams of black lava—and how black and shuddering those torrents are—which converge as you rise until they meet at Alta Vista. One hardly wonders at the "impossible" of the Spaniards when they looked at the ponderous mounting of Smyth's equatorial and heard him calmly propose to erect it at Alta Vista. For my "mulo" had surely used his last reserve of force, when he bore me forward upon the bit of level ground which forms the historic plateau and invited me to dismount by the side of the half ruined walls which marked the site of the "Astronomer's experiment."

The walls are quite well enough preserved to show fully the form and manner of the enclosure, and after visiting each apartment I sat upon a corner stone and looked up at the heavens. I had watched the sun as it passed to its setting behind the peak, and the earth's shadow as it rose distinct in the eastern heavens, as well as the rising of the moon out of the ocean from a point a thousand feet below. Now, at three o'clock in the morning, Jupiter was high in the heavens, one of the objects Smyth especially observed. The moon, Mars and Antares formed a triangle within a small area in Scorpio, while that whole constellation was spread upon the sky at an altitude that showed its beauties and suggestive form in a manner most striking and impressive to the northern eye.

An hour and a half later and I had climbed over the vast masses of black lava, and up the loose cindery side of the final cone, which make up the two thousand feet of height above Alta Vista, and stepped over the narrow brim into the white smoking crater. One is willing to wait a little before taking anything like a leisurely look from the pinnacle on which he finds himself standing, for it is a biting wind, "a nipping and an eager air," that sweeps through that rarified region, and there is an inviting warmth within. A little below the edge therefore, and sheltered by it, I drew close to a great opening through which came hot breaths from —somewhere,—sulphur laden but not suffocating.

The crater is about two hundred and fifty feet in diameter, and its concave floor sinks to a depth of sixty or seventy feet. The sulphur breath of the volcano has whitened the whole interior and the exterior also for a short distance from the top, which gives it the white-lipped appearance from a distance. Around the many escape pipes, through which the steaming fumes come, in some cases with a deep but not heavy roar, fine sulphur crystals are forming and the visitor may gather some which will be made for him "while he waits."

Looking across the crater, at the moon and Mars and the stars in their neighborhood, what strange contortions did the rising puffs and little clouds of heated vapor cause them to make. They danced, expanded, changed form and color in a manner most kaleidoscopic. Now looking to the

east, long radiating lines of vivid light strike upwards against the light clouds that float near the horizon, and make a golden pathway for the sun. Downwards, far, far below was spread, from beyond the great crater walls, the white, billowy surface of the clouds that covered the low valley of Orotava. Beyond these and on every side what a delicate azure is the ocean; how much more insubstantial it appears than the clouds; how softly upon its ethereal surface rest the other islands of the archipelago, one wrapped to its mountain summits in snowy cloud, seems to float upon the sea like a mass of softest down; another, cloudless, presents varied shades of greenish brown in the morning light, while the outline of its shore is marked upon the blue by a delicate line of white, the surf; and a third has its crests encircled by a broad thin horizontal ring of cloud. What a lovely object the earth must be if observed from a sufficient distance.

As the sun comes up from the great desert the shadow of the peak rises against the western sky. It is at this time that the lunar crater immediately below is seen in its most striking aspect. Except that the central peak is much higher than the walls, which rarely happens in the moon, one cannot avoid the conviction that the view is just what would be had from many a central peak there familiar to the telescopist. The old wall is not complete, but quite enough remains to show the part it has taken in the history of the volcano. On the eastern and south-eastern side a section throws its shadow over the floor of the crater, while the eastern or sunward side of the peak and the interior slopes and precipices of the southwestern wall, shine brightly in the light of the rising sun. The small craters and masses of lava which cover the floor are brought into high but temporary prominence by thin dark shadows. Radiating lines of red lava cover one part reaching out to the foot of the crater wall, while a shower of pumice has at some time been thrown over another part forming a smooth floor through which the points and ridges of the lava streams project. Guajara, the highest point of the wall on the south, has plainly to be seen on its rounded top the heap of stones piled by Smyth for the first part of the "Experiment." In every direction beyond the walls of the great crater can be seen the parasitic cones that at different times

have become the vents for the volcanic forces below, and these add familiar features to the lunar likeness.

It is well worth the effort to raise one's self, for once, as far above the clouds as one lives ordinarily below them, and learn how much more beautiful they may appear from above than from below, and for a telescopist there is no mountain like Teyde, for he may almost feel that he has been to the moon.

Santa Cruz, Teneriffe, May 19, 1890.

CHESTER SMITH LYMAN.*

Chester Smith Lyman was born Jan. 13, 1814, at Manchester, Conn., being the eighth lineal descendant of Richard Lyman who landed in America in a company of Puritans in the severe winter of 1635.

In boyhood Professor Lyman had the advantages of a common country school while working at intervals on a farm. At the age of nine years he showed unusual mechanical ingenuity in making toys, windmills, waterwheels, etc., as well as a great interest in Astronomy and the kindred sciences. Very few books of any kind were within his reach and those of a scientific character were even more scarce than others. He however, gained possession of one on natural philosophy, Gibson's Surveying and Bowditch's Navigation. From these books he learned the nature of lenses, and without a teacher, the rudiments of geometry and trigonometry and some knowledge of surveying and navigation. He extemporized a telescope for himself from a small burning glass, a yard stick and his mother's spectacles, and, in later life he said: "I can never forget the delight with which I turned this upon the Pleiades," and for the first time saw this cluster expanded into a large number of brighter stars.

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* The facts for the following brief sketch of the life and work of the late Professor Chester Smith Lyman are mainly taken from a well written article which appeared in the November number of the "Popular Science Monthly" for 1889. The frontispiece was made from a photograph kindly furnished bp Mary F. Lyman.

At thirteen he eagerly read Ferguson's Astronomy and ariticles on Optics and Astronomy in the Edinburg Encyclopedia. From thirteen to sixteen he spent most of his spare time in his father's tool shop constructing astronomical and other instruments from the diagrams of his few much prized books, such as a sextant, quadrant, celestial globe, orrery, eclipsareon, solar microscope and a Herschelian telescope four feet long which enabled him to see Jupiter's satellites and belts, Saturn's rings, the moon, and other celestial objects. He computed all the eclipses for fifteen years to come and made almanacs for 1830 and 1831. In order to give the places of the planets in these almanacs (never having seen a nautical almanac or astronomical tables of planets) he made rough tables for himself computing them from the elements of the planet's orbits as given in his book on natural philosophy. At the age of fourteen came his first experience in the study of the Latin, from which he derived the life-long conviction that the ordinary methods of teaching the classics consumes fully one-half more time than is necessary to accomplish the same results.

Two or three years later, leading business men of Manchester became interested in the mechanical and scientific pursuits of Mr. Lyman, and sought appointment for him to a cadetship at West Point. Pending this, he became interested in religious matters, and he determined instead of entering the military profession to pursue a college course of study and become a minister. To carry out this plan, he attended the Ellington school in June, 1832, a prominent preparatory school in New England, and fitted for college in twelve months' time, and in 1833 he entered Yale College without conditions. During his Junïor year, Mr. Lyman was one of the originators and editors of the Yale Literary Magazine. In addition to his regular studies, in which he took high rank, he was assistant to the Professor in Natural Philosophy and gave some attention to observations in progress at the Yale Observatory.

On graduating in 1837, he was offered several eligible positions, such as a professorship in a University, a place in the Wilkes' Exploring Expedition, an examinership in the Patent Office, etc., but he accepted for two years the superintendency of Ellington School, after which he attended

Yale and Union Theological Seminaries, then he occupied a short pastorate at the First Church in New Britain, Connecticut. Health failing, he took a sea voyage, and after seven and a half months he reached the Sandwich Islands, where he remained a little more than one year. While at this place he visited and mapped the volcanic crater of Kilauea, afterwards fully described in the "American Journal of Science." The great rainfall at Hawaii led Mr. Lyman to construct an ingenious, self-registering rain gauge, so that an accurate measure of the total annual rainfall could be known. It was found to be over ten feet. While at this place he also taught the Royal School, for a few months, having among his pupils four young chiefs and a young woman who later was known as Queen Emma. The young chiefs also all subsequently occupied the Hawaiian throne.

In July, 1846, Mr. Lyman returned to California, and being a practical surveyor soon found employment in San Francisco, just then newly laid out, and not having buildings enough anywhere to show the direction of any street but that of Montgomery. He was also employed in various parts of California in surveying ranches and towns, especially in the region southward towards San José which place he was employed to resurvey. He made the original survey of the famous New Almaden quicksilver mine, probably the richest mine of the kind in the world.

In May 1847 gold was discovered at Sutter's Mill on the American river, about one hundred and fifty miles to the north. Soon Professor Lyman and his surveying party visited that point, and the letters which he wrote to the Eastern papers concerning the gold discovery were among the first authentic accounts published, and his articles awakened very unusual interest. He did not stay long in this region; his health being restored he returned to New Haven in 1850, and in June was married to Miss Delia W. Wood, daughter of Hon. Joseph Wood. He settled permanently in New Haven, and again engaged in literary and scientific work, part of which was the preparation of definitions of scientific words for the new editions of Webster's Dictionary. In 1859 he became Professor of Industrial Mechanics and Physics in Yale College, taking an active part in the organization of the Sheffield Scientific school in which he taught Astronomy.

In 1871 his chair in this school was changed to astronomy and physics. In 1884, on account of his impaired health, he resigned the chair of physics, but still retained the Sheffield Professorship of Astronomy from the organization of the school in 1860.

Professor Lyman was the original inventor of the combined transit instrument and zenith telescope for determining latitude by the Talcott method. It was constructed by him in 1852–53, and was described in the American Journal of Science. This was ten years before the account of a like instrument appeared by Davidson.

As we have before said, Professor Lyman was actively interested in the establishment of Yale Observatory, and was one of its board of managers. It will be easily remembered by all readers, too, that he was the first to observe the delicate ring of light around Venus at inferior conjunction in December, 1866, and also before and after the transit of Venus in 1874. As a thorough scholar, a successful instructor and an original investigator, Professor Lyman was eminent, and well and widely known in the literary and scientific circles of the world.

MOTIONS OF PLANETARY NEBULÆ IN LINE OF SIGHT.

A very suggestive paper with title "On the Motions of the Planetary Nebulæ in the Line of Sight," has been published by James E. Keeler, of the Lick Observatory, in No. 11 of the Publications of the Astronomical Society of the Pacific. This paper contains a preliminary account of the researches in the spectra of the planetary nebulæ, and a statement of the results of measurements which show that some of the nebulæ which have hitherto been supposed to be at rest relatively to the solar system, have a considerable motion in the line of sight. The paper also gives a careful description of the different spectroscopes used and the objects observed. It is further stated "that in seeking to determine the motions of the nebulæ from these observations, a difficulty presented itself which does not occur in the observations of stars in line of sight. The origin of the brightest nebular line is unknown, and hence we have no terrestrial substance

with which to make a direct comparison. The position of that nebular line must therefore be determined in some other way. This was done by observations of nebulæ distributed with some degree of uniformity throughout the sky, assuming the mean position of the line as that due to a nebula without motion. The residuals obtained by comparing the individual results with this mean would represent the corresponding displacement of the line for each nebula. A table of the observations of a few nebulæ is made in this way as follows:

Motions of Planetary Nebulæ in the Line of Sight.

(A positive sign signifies recession; a negative sign approach.)

Nebula.	λ	Displacement.	Motion per Second.
	Tenth-meters.	Tenth-meters.	Miles.
G. C. 4234 (Σ 5)	5005.38	− 0.30	− 11.2
G. C. 5841	5005.50	− 0.18	− 6.7
G. C. 4373	5005.85	− 0.83	− 31.0
G. C. 4390 (Σ 6)	5005.81	+ 0.13	+ 4.8
N. G. C. 6790	5006.71	+ 1.03	+ 38.4
G. C. 4510	5005.65	− 0.03	− 1.1
G. C. 4514	5005.87	+ 0.19	+ 7.1
G. C. 4628	5005.22	− 0.46	− 17.2
N. G. C. 7027	5006.13	+ 0.45	+ 16.8
G. C. 4964	5005.72	+ 0.04	+ 1.5
Mea	5005.68		

It is probable that a greater number of nebulæ would give a somewhat smaller mean wave-length for the position of the brightest line, and that therefore the motions of approach in the above table are too small. The single comparison of the third line in the spectrum of Σ 6 with the hydrogen line $H\beta$ also indicates a higher mean position of the nebular line, although the observation was subject to rather large accidental errors. The *difference* of motion of the nebulæ given in the table above I believe to have a considerable degree of accuracy,—*i. e.*, that the errors do not much exceed two or three English miles.

The spectra of the nuclei of planetary nebulæ have a remarkable resemblance to the spectra of the Wolf-Rayet and other bright-line stars, and intimate connection between these objects, if established by further observations, would

place the bright-line stars first in the order of development. The D_3 line appears in the central condensation of a number of bright nebulæ, and, with sufficient light, would probably be seen in many of them, and this line is also prominent in most of the bright-line stars. Other lines in the nebulæ and stars are probably of identical origin. At my request Mr. Burnham and Mr. Barnard examined the Wolf-Rayet stars in Cygnus for traces of surrounding nebulosity with only negative results."

At the close of this paper Mr. Keeler appends the following note:

"Since my paper was printed, I have seen No. 293 of the Proceedings of the Royal Society, in which Mr. Lockyer describes his recent observations, and arrives at conclusions which cannot be reconciled with my own. There is, however, nothing that I could wish to change in my paper, since it is simply a record of observed facts. In only one place (observations of Σ 6) have I referred the observed appearances to a cosmical theory, and the reader can easily supply any other explanation that is in accordance with the facts.

The errors which Mr. Lockyer mentions as liable to arise from imperfect adjustment of the collimator axis and from parallax, seem to me excessive, if the telescopes are good and the adjustments are carefully made, and if they existed they would make observations of motion in the line of sight impossible. Certainly no errors approaching them in magnitude are produced in my own apparatus, when, in testing for constant errors, the various adjustments were purposely disturbed by amounts greater than could occur in practice. Among the many experiments which were made was the one suggested by Mr. Lockyer—rotating the spectroscope 180° between measures, but no appreciable effect was produced upon the position of the nebular line.

As regards accuracy of positions, there is a great advantage in using a very high dispersion, such as was employed in these measures, since any angular displacement of the parts of the apparatus produces but a small error measured in wave-lengths. The measures are also *differential*, the reference line being in the same field and the telescope fixed in position. They are affected by any error in the assumed place of the reference line, but this is immaterial for the purposes of the investigation.

On referring to my measures, it will be seen that they apparently have a vastly higher degree of accuracy than that which Mr. Lockyer considers attainable. When it is remembered that these measures were made on different nights (the spectroscope usually having been dismounted in the interval), and frequently without any recollection of the results previously obtained, it appears in the highest degree improbable that the agreement of the different results for the same object should be the result of accident. In the observations of the motion of Venus in the line of sight the interval between the *D* lines appeared under an angle of 1° 17′, as viewed with the eye-piece, and any good observer, on noting the small displacement of the lines of the planet, would admit the possibility of measuring this displacement to within a tenth of its value. Hence the accuracy of the measures in this case cannot be regarded as accidental, and for the nebulæ, on which even a higher dispersion was employed, the probable error of a setting was not much greater.

In regard to the *character* of the chief nebular line I can only repeat that I see no tendency in it to assume the fluted appearance described by Mr. Lockyer either in the nebula of Orion or in the others I have observed, some of which are fainter, and some very much brighter. Near the nucleus of a nebula, if it has one, the lines are broader and hazy, but equally so on both sides, and, as nearly as their different degrees of brightness will allow one to judge, all the lines are affected alike.

For faint, extended nebulæ, the great focal length of the thirty-six inch equatorial is a positive disadvantage, and I do not attach much weight to the negative results obtained in the examination of some of these objects giving continuous spectra.

HOW TO MEASURE THE INVISIBLE.*

HENRY M. PARKHURST.

When Comte's Positive Philosophy was published, some forty years ago, Kirchhoff had not made the discovery which

* A lecture delivered before the astronomical department of the Brooklyn Institute, October 13, and illustrated with lantern views and diagrams. The remainder of the lecture will be given next month with the illustrations.

lies at the foundation of all spectroscopic analysis. It seemed then that there could be no question of the correctness of his assertion that the chemistry of the stars would be forever beyond the reach of human investigation. What could be more certainly impossible than that men of science, separated from the stars by millions of millions of miles of space, void with the exception of a possible ether, so etherial as not to perceptibly interfere with the motion of the rarest comets, could ascertain what substances exist, and their chemical nature, in those inconceivably distant orbs? His reasoning was good; but his argument contained a flaw in assuming as a self-evident fact that which was not a fact. The sense of sight alone can give us information with regard to the stars. No sound can cross the depths of space: still less can our other senses aid us; for they require close proximity if not actual contact as the basis of their indications. Comte argued that all that we could learn of the stars must be learned through the instrumentality of the sense of sight; and he assumed that it was absolutely impossible for us by the sense of sight to distinguish between the different chemical elements in the stars. Yet the discovery of the principle of the spectroscope has made this seeming impossibility possible. Comte's system of Positive Philosophy was founded upon the assumption that there were some things that men positively could not know; that it was useless to look for it or to hope for it; and this was one of them. Let me read to you his exact language:

"Of all objects, the planets are those which appear to us under the least varied aspect. We see how we may determine their forms, their distances, their bulk, and their motions, but we can never know anything of their chemical or mineralogical structure; and, much less, that of organized beings living on their surface."

Although the word "planets" is used in the translation of this sentence, it is of the stars that he is speaking, and the argument applies equally to the planets and the fixed stars. The fact that to-day, what he pronounced forever impossible, and there was no one to tell him nay, has already been attained, should be a lesson to us never to be positive of the impossibility of attaining any sort of knowledge. Whatever knowledge man has sufficient conception of to imagine

a theory with regard to, there is, so far as we know, a possibility of his reaching, in some way and at some time. As with regard to the mathematical computation that no steamship could ever cross the Atlantic, because the coal would not furnish sufficient power for its own transportation, it seems as if the very announcement of an impossibility, served but as a prelude to emphasize the marvellous achievement.

Before the invention of the telescope an object upon the moon's surface fifty miles in diameter could not be seen; and it seemed impossible that men should ever know anything about lesser objects. By the argument of Comte, man was forever debarred from knowing about such objects. Leaving out of view the possibility of optical magnification, the sense of sight having already reached the limit of its power, there was no basis left for further discoveries; and among absolute impossibilities, quality was no more to be rejected as unattainable than quantity. The invention of the telescope has introduced a new element before unthought of; and it has taught us the first mode of measuring the invisible; which is, first to make it visible, by magnifying it optically. The thousands of minute craters upon the moon's surface can now be measured; whereas before the invention of the telescope their existence could not be suspected. We have not yet learned what limitation attends this mode of magnification. Each new large telescope, making visible and measurable that which was before invisible, leads to the construction of another larger telescope; and the end is not yet. The great refractor of the National Observatory, when I was there, had an aperature of less than ten inches. Then came the Harvard refractor of fifteen inches. The Chicago telescope of eighteen inches suceeded. Others still larger followed, until the new refractor of twenty-six inches aperture replaced the old one at Washington. At last has come the Lick telescope of thirty-six inches, eclipsing all predecessors. And even now the Clarks are engaged in the construction of a still larger telescope, which is expected to excel even the Lick telescope.

Not only may we have larger telescopes, but new discoveries in the manufacture of the lenses may so improve their definition, by getting rid of the irrationality of the spectra,

as to still further increase their magnifying power. Such improvements cannot add much in the observation of excessively faint objects, but may add materially in observations where definition is required rather than light.

It will take many years to double the power of our largest telescopes, if it can ever be done; and it is natural to suppose that the power of measurement must await the improvement of the telescope. We may measure the invisible by first making it visible; but how can we measure it if we cannot make it visible? The sight is our only sense which reaches beyond our own little planet. If we cannot take cognizance of a distant object by our vision, how can we know that it exists?

One answer to this question it is not difficult to find. In an eclipse of the sun, we cannot see the moon; but we know that it exists from its intercepting the rays of the sun. Even if we never saw the moon at any other time, we should know in a solar eclipse that it existed. Or if that is considered too metaphysical, I will pass at once to another illustration.

The irregularities in the proper motion of Procyon have been found to indicate that it is accompanied by a body invisible to us, and yet of sufficient mass perceptibly to affect its motion. Procyon and this invisible body revolve around a common center of gravity. We know that this dark body exists, and we know approximately its direction from Procyon and the period of its revolution. But these facts do not give us any means of measurement. We cannot learn from these facts, so far as I can see, anything whatever with regard to the distance between the bodies, or their relative size, or absolute size, or anything which can properly be called a measurement. In like manner and still earlier, Sirius was found to have an irregular proper motion, inducing the belief that it was attended by an invisible companion. The subsequent discovery of the companion of Sirius, very faint but of considerable size, while it confirms the hypothesis of the cause of the irregularities in the motion of Procyon, makes it no longer possible to cite Sirius as an illustration of a bright star attended by a known invisible companion.

It has long been thought not improbable that the variable star, Algol, is accompanied by a dark body which at each

revolution, comes between us and the principal star, and cuts off a portion of its light, causing its brightness to fall from the second to the fourth magnitude. Here all that we see, and all that any telescope can show us, is the diminution of the light. If we knew that the dark body passed directly and centrally between us and the bright star, this would give us an approximation to the relative sizes of the two bodies; but even upon that hypothesis we could not know their actual size or distance. It is manifest that if the plane of the orbit should be, as it would be most likely to be, inclined to the line of sight (the line joining Algol and the earth), the dark body might not pass entirely across the disk of the other; so that it is impossible to say how much larger the dark body is. In the existing state of our knowledge it seems probable that the dark body is the smaller of the two. It is difficult to understand how one body can be glowing with heat, while another body of equal or larger size, under very similar conditions, is so cooled down as to cease to be luminous. To reduce this difficulty as much as possible, it is assumed that the dark body passes nearly centrally over the other at each revolution, and that its size is only enough to account for the amount of light obstructed. This does not remove the difficulty, but it reduces it. In any event there is so much hypothesis mixed with our known facts that our results cannot properly be called results of measurement, and such results are not measures of the invisible.

Yet we are not left to mere hypothesis in this case. The telescope enables us to measure the invisible by first making it visible; the spectroscope enables us to measure the invisible without making it visible; and this is the matter which I wish to-night specially to explain.

Let me first remark that the spectroscope not only upsets our preconceived notions of the possibilities of things, but reverses the order of its revelations. When an object is presented to our view, we first form some idea of its form, its distance and its size; and the investigation of its nature, and the nature of the substances of which it is composed, comes afterwards. But in these mysterious revelations of the spectroscope in the stellar universe, it first revealed to us the nature of the substances of which the stars were composed;

then whether gaseous or solid, whether of a high or low temperature; and its last achievement is the measurement of distances and of masses.

The principal star in the constellation Capricornus, is a double-star known before the invention of the telescope. The apparent distance of the two stars is about 6′. Soon after the application of the telescope to astronomical research it was found that there were much closer double-stars, so close as not to be distinguishable by the naked eye. Every advance in the improvement of the telescope has brought to our knowledge still closer double-stars, the distance between them being so magnified as to become visible and measurable. But the spectroscope has revealed to us a double-star so close that no telescope will show the distance between the two stars, although each one of the two stars is bright enough to be visible to the naked eye; and I shall endeavor to explain to you how it is capable theoretically of revealing to us the duplicity of stars so optically close that no possible telescope of the future could ever separate them.

In order to make this intelligible, it will be necessary for me to explain what the spectroscope is, and how it gives us information. As preliminary to that, and to make its indications certain, on their face, I must speak of the nature of light, and especially of color. I shall speak of these points with sole reference to explaining and demonstrating this latest achievement of the spectroscope.

I will not go back in the history of the spectroscope to the time of the flood, when the colors of the rainbow first attracted attention; but will begin with the time of Newton, who in 1664 studied those same colors produced by refracting the sun's rays through a glass prism. He found the solar rays to consist of rays of different degrees of refrangibility. When the aperture through which the sunlight was received upon the prism was a circular hole in the shutter, each kind of light formed a circle in a different place, according to its refrangibility, the different circles lapping over each other and mingling their colors. By changing the form of the aperture to a slit, he found that the colors became much more pure. Carrying out the same plan to greater perfection Wollaston observed in 1802 some of the principal dark lines in the spectrum, which he considered as the boundary lines

between the different pure colors. These lines were carefully observed and mapped by Fraunhofer in 1814. Were the rays of light of all degrees of refrangibility between certain limits, there would be no dark lines. In the continuous spectrum of an incandescent non-volatile substance, such as carbon under ordinary conditions there are no dark lines. The existence of these dark lines in the sunlight shows that there are certain degrees of refrangibility which do not exist in the sunlight as it comes to us. It was the discovery by Kirchhoff in 1859 of the cause of this, of the way in which these kinds of rays in the original light from the incandescent body of the sun are weeded out of the continuous spectrum by glowing gases in the sun's atmosphere, which was the first step in the science of spectroscopy.

When common salt is put into the flame of a Bunsen burner, instead of its light becoming diffused in a continuous spectrum, it is wholly confined to two narrow lines, close together. Upon comparing the position of these two lines with the lines of the solar spectrum, it had been found that they exactly, or at least very nearly, corresponded with Fraunhofer's two D lines. Kirchhoff traced the identity of the lines, and showed it demonstrated the existence of the vapor of sodium in the sun's atmosphere. It is remarkable how nearly the discovery had been made many years before. Even before the discovery of the lines in the solar spectrum, Euler, reasoning from the nature of wave motion, had enunciated the principle that "Every substance absorbs light of such a wave length as coincides with the vibrations of its smallest particles."

Again, in 1853, Angstrom enunciated the principle that "A luminous gas absorbs rays of the same refrangibility as those which it emits." But although these principles were enunciated, there does not appear to have been any attempt to verify them by experiment, or any clear conception of the resulting consequences, until the observations of Kirchhoff in 1859. From direct comparison of the two bright sodium lines with the two dark D lines of the solar spectrum, and from observation of the effect of a sodium flame to produce the same two dark lines when a bright light shone through it, Kirchhoff was convinced of the existence of the vapor of sodium in the sun's atmospher, and at once

proceeded to investigate what other chemical elements could be found to exist in the sun's atmosphere by the appearance of their lines in the solar spectrum. His most remarkable result was the discovery that more than sixty dark lines in the solar spectrum exactly coincide with as many of the bright lines produced by the vapor of iron; demonstrating the existence of iron in the form of vapor in the sun's atmosphere. And later there have been found to be no less than 460 iron lines in the solar spectrum. Various other chemical elements are also identified. But for my present purpose it is enough to have made it apparent that the cause of the dark lines in the spectrum of the sun and of the stars is known, and that we can safely rely upon the conclusions which follow from the phenomena which we observe in relation to them.

(TO BE CONTINUED.)

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at superior conjunction with the sun on Nov. 16, so that he will not be in good position for observation during November.

Venus is approaching inferior conjunction, and although very brilliant cannot be well observed after sunset. The best views are obtained from one to two hours before sunset. The diameter of Venus' disk increases from 44.4″, Nov. 2, to 64.6″, Dec. 3, when the planet, at 10^h P. M., will be in conjunction with the sun, at a distance of only 15′ from the sun's southern limb. The phase of the planet decreases in the same time from 0.224 to 0.000. On Nov. 29, at 1:30 P. M., Mercury and Venus will be in conjunction, Mercury being only 10′ north of Venus. This conjunction will, however, occur so close to the sun that it will probably be impossible to see either of the planets.

Mars continues to set at about the same time each evening, in the southwest. His progress eastward among the stars is very noticeable. He will pass by Jupiter on Nov. 13 at 5 P. M., passing 59′ south of the latter. The diameter of Mars' disk is now so small and his altitude so low in the evening that no satisfactory views of his surface can be obtained.

A friend sends us a clipping from the Washington *Evening Star*, Oct. 11, 1890, giving an interesting note, in which Professor W. H. Pickering is represented as thinking that the planet Mars is dying. He, however, says "It is all a hypothesis after all. There is no definite proof. We know that there are great patches of white in the polar regions of the planet and that they increase in winter and diminish in summer. This fact is abundantly

confirmed by the photographs taken by the Harvard College astronomers at our station on Mount Wilson in Southern California. On the night of the 10th of April we took an observation and on the succeeding night another one. On the second occasion we found that the white space in the southern hemisphere had increased twenty during the four hours by an area nearly as large as the United States. So you see if this white appearance is due to snow there must have been a tremendous snow-storm in Southern Mars on the 10th of April."

In this connection a note from a recent letter from Mr. Charles Burckhalter, of Chabot Observatory, will be interesting. He gives the following transcript from his note book: "June 9th observed Mars, and, as usual the northern snow cap appeared the larger, but on the 10th, I saw at a glance that the southern cap was twice as large as the northern." He then put down more for amusement than anything else this query: "Was there a great snowstorm at the south pole of Mars between June 9 and 10, 1890."

Whether we may interpret the white appearance of the poles of Mars as due to the presence of snow or of clouds, we have abundant evidence of great and sudden changes in them. The fact that two astronomers widely separated, interpret similar phenomena in the same way shows at least that their interpretation is a natural one.

Jupiter is moving forward again through the constellation Capricorn. The procession of the three bright planets descending toward the southwest horizon in the early evening, has been a noticeable one during the past month, Venus leading, Mars following and Jupiter bringing up the rear in their diurnal motion. Jupiter will catch up with Mars, or rather Mars will catch up with Jupiter in his eastward motion on Nov. 13. It will help our understanding of the different distances of celestial bodies apparently close together, to know that the distance of Mars on Nov. 13 will be about 119,000,000 miles, while that of Jupiter, in almost the same direction, will be 486,000,000 miles.

On the night of Sept. 8, while Mr. Barnard was observing Jupiter with the 12-inch equatorial of the Lick Observatory, he noticed that Satellite I, in transit across the disc of the planet, appeared to be double. "Upon applying high powers (500 and 700 diameters), and with as perfect seeing as we have ever had on the mountain, the satellite distinctly appeared double, the apparent components being in a line nearly vertical to the belts of Jupiter. A line of light was occasionally seen separating the satellite into two nearly equal parts." Mr. Burnham also distinctly saw the phenomenon of duplicity. Mr. Barnard says: "There are only two explanations of what we saw. A white belt on the satellite parallel to the belts of Jupiter, would, perhaps, satisfactorily explain the phenomenon. If this is not the explanation, there is no other alternative but to consider the satellite actually double. Its shadow was apparently round. The satellite was examined when off the planet later, but the images were too indifferent to decide upon anything."

Saturn may be observed in the morning. He is in the eastern part of the constellation of Leo, seen toward the east after 2 A. M. The angle of the earth from the plane of the rings is now only 3° and decreasing, so that

the rings are seen almost edgewise, and therefore indistinct. We give this month the times of elongation of the five brighter satellites of Saturn, which can be seen with telescopes of moderate power.

Uranus is too nearly in line with the sun to be seen during this month.

Neptune will be at opposition Nov. 27, and is therefore in excellent position for observation. He is at nearly 20° north declination, so that in our latitude he reaches a very high meridian altitude. He may be found in Taurus almost on a line from Aldebaran to the Pleiades, 1° west and 45′ north of the fourth magnitude star ε Tauri, almost exactly north of the sixth magnitude star which follows ε Tauri.

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			MERCURY.		
Nov. 25	16 25.4	− 22 53	7 40 A. M.	12 06.9 P. M.	4 33 P. M.
Dec. 5	17 32.9	− 25 17	8 21 "	12 35.0 "	4 49 "
15	18 42.1	− 25 23	8 52 "	1 03.5 "	5 15 "
			VENUS.		
Nov. 25	17 01.2	− 25 24	8 30 A. M.	12 42.7 P. M.	4 56 P. M.
Dec. 5	16 38.0	− 22 18	7 11 "	11 40.2 "	4 09 "
15	16 18.2	− 19 08	5 57 "	10 41.1 "	3 25 "
			MARS.		
Nov. 25	21 08.8	− 18 00	12 00 M.	4 49.4 P. M.	9 39 P. M.
Dec. 5	21 38.1	− 15 31	11 39 A. M.	4 39.1 "	9 39 "
15	22 06.8	− 12 49	11 16 "	4 28.5 "	9 40 "
			JUPITER.		
Nov. 25	20 40.4	− 19 08	11 37 A. M.	4 20.7 P. M.	9 05 P. M.
Dec. 5	20 47.4	− 18 41	11 02 "	3 48.4 "	8 35 "
15	20 55.2	− 18 10	10 28 "	3 16.7 "	8 05 "
			SATURN.		
Nov. 25	11 12.2	+ 7 05	12 21 A. M.	6 54.5 A. M.	1 28 P. M.
Dec. 5	11 14.2	+ 6 56	11 43 P. M.	6 13.3 "	12 44 "
15	11 15.4	+ 6 51	11 05 "	5 35.1 "	12 06 "
			URANUS.		
Nov. 25	13 49.6	− 10 43	4 11 A. M.	9 31.6 A. M.	2 52 P. M.
Dec. 5	13 51.3	− 10 53	3 34 "	8 54.1 "	2 14 "
15	13 53.4	− 11 04	2 58 "	8 16.7 "	1 36 "
			NEPTUNE.		
Nov. 25	4 15.3	+ 19 35	4 35 P. M.	11 54.8 P. M.	7 15 A. M.
Dec. 5	4 14.2	+ 19 32	3 54 "	11 14.3 "	6 35 "
15	4 13.0	+ 19 29	3 13 "	10 33.9 "	5 54 "
			THE SUN.		
Nov. 20	15 44.5	− 19 49	7 05 A. M.	11 45.9 A. M.	4 27 A. M.
25	16 05.8	− 20 52	7 11 "	11 47.3 "	4 23 "
30	16 27.2	− 21 44	7 16 "	11 48.0 "	4 20 "
Dec. 5	16 48.9	− 22 27	7 23 "	11 50.9 "	4 19 "
10	17 10.8	− 22 58	7 28 "	11 53.1 "	4 19 "
15	17 32.9	− 23 18	7 32 "	11 55.5 "	4 19 "
			THE MOON.		
Nov. 20	23 27.8	− 9 11	1 58 P. M.	7 28.2 P. M.	1 10 A. M.
25	3 52.9	+ 18 53	4 04 "	11 32.8 "	7 13 "
30	8 33.9	+ 22 57	7 55 "	3 53.5 A. M.	11 44 "
Dec. 6	12 32.4	+ 1 50	1 08 A. M.	7 31.5 "	1 45 P. M.
11	16 53.0	− 22 32	6 53 "	11 31.7 "	4 01 "
15	21 14.5	− 20 48	10 55 "	3 37.0 P. M.	8 26 "

Phases and Aspects of the Moon.

			Central Time. d	h	m	
First Quarter	1890	Nov.	19	6	45	A. M.
Full Moon	"	"	26	7	23	"
Last Quarter	"	Dec.	4	7	27	A. M.
New Moon	"	"	11	9	11	P. M.
Perigee	"	Nov.	18	12	00	M.
Apogee	"	Dec.	3	12	24	A. M.
Perigee	"	"	14	6	36	P. M.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N.P't. °	Duration. h m
Nov. 18	B.A.C. 7550	6½	8 32	143	8 58	185	0 26
28	ε Geminorum	3½	11 19	24	12 04	317	0 45
29	κ Geminorum	3½	14 35	82	16 02	297	1 28
Dec. 1	B.A.C. 3206	6½	12 40	116	14 00	272	1 20
2	η Leonis	3½	9 58	53	10 36	329	0 38

Saturn's Satellites.

[Central Time; E = eastern elongation; I = inferior conjunction; W = western elongation; S = superior conjunction.]

JAPETUS.

Nov. 18	W.	Dec. 8	S.	Dec. 28	E.

TITAN.

Nov. 15	6.2 A. M. E.	Nov. 27	6.1 A. M. S.	Dec. 9	5.7 A. M. W.
19	6.2 " I.	Dec. 1	6.1 " E.	13	5.5 " S.
23	6.2 " W.	5	5.9 " I.		

RHEA.

Nov. 16	8.3 A. M. E.	Nov. 29	9.8 P. M. E.	Dec. 13	11.1 A. M. E.
20	8.8 P. M. E.	Dec. 4	10.3 A. M. E.		
25	9.3 A. M. E.	8	10.7 P. M. E.		

DIONE.

Nov. 16	5.6 A. M. E.	Nov. 26	4.3 A. M. E.	Dec. 7	3.2 A. M. E.
17	11.2 P. M. E.	28	10.1 P. M. E.	9	8.9 P. M. E.
20	4.9 P. M. E.	Dec. 1	3.8 P. M. E.	12	2.6 P. M. E.
23	10.6 A. M. E.	4	9.5 A. M. E.	15	8.3 A. M. E.

TETHYS.

Nov. 15	7.2 P. M. E.	Nov. 25	5.9 A. M. E.	Dec. 4	4.4 P. M. E.
17	4.6 P. M. E.	27	3.2 A. M. E.	6	1.7 P. M. E.
19	1.9 P. M. E.	29	12.5 A. M. E.	8	11.0 A. M. E.
21	11.2 A. M. E.	30	9.8 P. M. E.	10	8.4 A. M. E.
23	8.5 A. M. E.	Dec. 2	7.1 P. M. E.	12	5.7 A. M. E.
				14	3.0 A. M. E.

Phenomena of Jupiter's Satellites.

Central Time.	h. m.			Central Time.	h. m.		
Nov. 17	5 03	P. M.	II. Sh. Eg.	Dec. 1	5 00	P. M.	II. Tr. In.
17	6 02	"	I. Oc. Dis.	3	4 30	"	I. Oc. Dis.
18	5 33	"	I. Tr. Eg.	3	4 37	"	II. Ec. Re.
20	5 23	"	III. Sh. In.	4	5 08	"	I. Sh. Eg.
24	5 12	"	II. Tr. Eg.	11	4 45	"	I. Sh. In.
25	5 12	"	I. Tr. In.	12	4 18	"	I. Ec. Re.
25	6 23	"	I. Sh. In.				
26	5 59	"	I. Ec. Re.				

Minima of Variable Stars of the Algol Type.

	R.A. h m s	Decl. ° ′	Central Times of Minima.
U Cephei	0 52 32	+ 81 17	Nov. 17, 6 P.M.; 22, 6 P.M.; 27, 5 P.M.
			Dec. 2, 5 P.M.; 7, 4 P.M.; 12, 4 P.M.
Algol	3 01 01	+ 40 32	Nov. 17, 10 P.M.; 20, 7 P.M.; Dec. 7, midn
			Dec. 10, 9 P.M.; 13, 5 P.M.
λ Tauri	3 54 35	+ 12 11	Nov. 15, 11 P.M.; 19, 9 P.M.; 23, 8 P.M.
			Nov. 57, 7 P.M.; Dec. 7, 6 P.M.; 5, 5 P.M.
R Canis Maj.	7 14 30	− 16 11	Nov. 23, 3 A.M.; 24, 6 A.M.; Dec. 1, 2 A.M.
			Dec. 2, 5 A.M.; 10, 4 A.M.
S Cancri	8 37 39	+ 19 26	Nov. 18, 1 A.M.; Dec. 6, midn.

Solar prominences for September 1890. Number of observations, 10; number of prominences, 36; mean number of prominences, 3.6; highest prominence, 96″ (on the 29th).

DISTRIBUTION OF PROMINENCES IN LATITUDE.

Between	E. Limb.	W. Limb.	Between	E. Limb.	W. Limb
0 and + 10°	0	3	0 and − 10°	5	2
+ 10 and + 20	0	2	− 10 and − 20	1	0
+ 20 and + 30	0	2	− 20 and − 30	2	0
+ 30 and + 40	0	3	− 30 and − 40	1	1
+ 40 and + 50	0	0	− 40 and − 50	0	0
+ 50 and + 60	0	1	− 50 and − 60	0	0
+ 60 and + 70	0	0	− 60 and − 70	0	0
+ 70 and + 80	0	0	− 70 and − 80	2	0
+ 80 and + 90	3	3	− 80 and − 90	0	5
				14	22

Camden Observatory, Oct. 1, 1890.

Smith Observatory Observations: The following solar observations were made with telescopes unless otherwise stated. They were taken by Charles E. Peet:

1890.	90° Mer. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
Sept. 16	5:45 p m	2	6	1	Bad.	
17	2:05 p m	2	12	0	Fair.	Gran. good.
18	5:20 p m	2	10	0	Fair.*	
20	8:05 a m	1	8	0	Good.	Gran. good.
21	5:15 p m	0	0	1	Fair.	Fac. mottlings on NE limbs.
22	5:30 p m	0	0	1	Poor.*	
23	1:25 p m	0	0	2	Good.*	
24	3 p m	0	0	0	Bad	Seeing too poor to distinguish.
26	2:35 p m	1	22	0	Good.	Veil about 3 of the spots.
27	2:25 p m	1	10	0	Bad.	
28	12:50 p m	1	9	0	Fair.	Gran. good.
30	2:50 p m	1	3	0	Bad.	Seeing too poor to distinguish much.
Oct. 2	2:35 p m	1	2	1	Poor.*	Large faculous regions about spots.
3	1:25 p m	0	0	1	Fair.*	Gran. large.
5	3 p m	1	2	0	Bad.*	Glimpsed thro' clouds for one moment.
6	2:15 p m	1	2	0	Bad.*	Glimpsed through clouds.
7	2:30 p m	1	3	1	Good.*	Gran. good.
10	3:45 p m	0	0	0	Bad.*	Haze thick.
12	3:00 p m	0	0	0	Fair.	
14	1:20 p m	1	2	0	Bad	CHAS. A. BACON.

* Projection on 20 cm. circle.

Carleton College Sunspot Observations. **(Continued form page 325.)**

1890.	Central Time.	Groups.	Spots.	Faculæ.	Observers.	Remarks.
July 15	9:15	0	0	2 gr.	C. R. W.	2 large gr. of fac. 1 E. and 1 W.
16	2:00	0	0	1 "	"	Fac. W.
17		0	0	0 "	"	
23	10:00	2	6	3 "	H. C. W.	Small spot with large gr. of fac. S. of centre. Large spot with a few smaller ones and many fac. near SE. limb.
26	12:30	1	10	0 "	"	Large spot followed by smaller ones.
28	10:00	2	6	1 "	"	New large spot near E. limb.
29	12:30	3	9	3 "	"	New small spot in SE. quadrant. Large spot near E. limb followed by large gr. of fac.
31	12:30	2	3	3 "	"	New gr. of July 29 has disappeared. Large spot of July 23 diminished to two very small spots.
Aug. 1	12:40	3	9	2 "	"	New gr. of spots SE. of center, probably a revival of gr. of July 29. New gr. fac. at SE. limb.
4	12:35	1	4	2 "	"	The large spot of July 28 is breaking up.
5	12:50	2	12	2 "	"	New gr. of 8 small spots SE. of center.
6	5:05	2	9	2 "	"	
8	12:05	0	0	1 "	"	Large gr. of fac. near NW. limb.
9	12:35	0	0	2 "	"	Fac. NW. and W.
11	12:45	1	2	1 "	"	2 new small spots NW. of center. Fac. W.
13	12:20	0	0	5 "	"	5 single fac. near different points of limb.
14	4:40	1	2	0 "	"	2 small spots near E. limb.
15	12:10	0	0	0 "	"	
19	12:15	0	0	1 "	"	Fac. SE.
21	4:50	0	0	0 "	"	
22	11:50	1	1	0 "	"	One small spot about ¼ way from center to S point of limb.
25	12:30	1	6	1 "	"	Large gr. of fac. with a few spots at E. limb.
26	12:40	2	27	3 "	"	Gr. near E. limb has broken up into many small spots. New gr. near W. limb.
27	9:45	2	33	2 "	"	
28	12:15	1	30	1 "	"	
29	10:50	1	25	0 "	"	
30	12:20	1	30	0 "	"	2 fine large spots.
Sept. 1	12:30	2	35	0 "	"	New gr. on S. hemisphere.
5	10:30	2	12	0 "	"	
9	1:35	1	7	0 "	"	
13	12:30	0	0	0 "	"	
16	12:30	2	4	1 "	"	One large spot SE. Gr. of 3 smaller spots further W. Fac. NW.
19		3			H. C. W.	
22	10:30	0	0	2 "	C. R. W.	Two large gr. of fac., 1 SE., 1 W.
23	12:45	0	0	2 "	"	Gr. of fac. on the E. larger and less brilliant than on 22d.
24	2:00	1	8	2 "	H. C. W.	
27	12:40	1	10	1 "	C. R. W.	Faculæ SW.
29	9:25	1	11	1 "	"	Faculæ SW.
30	2:10	1			"	
Oct. 1	3:40	1	4	1 "	"	
4	12:35	1	2	4 "	"	
14	2:30	1	2	2 "	"	Spots small. One gr. fac. E., other W.
15	12:30	0	0	2 "	"	One gr. fac. E., other W.
16	10:20	0	0	0 "	H. C. W.	
17		0	0	0 "	W. W. P.	
20	9:25	2	11	2 "	C. R. W.	2 gr. of spots near E. limb. One gr. very small and surrounded by fac.
21	12:30	2	17	1 "	"	One gr. finely developed containing 15 spots.
22	12:30	2	17	1 "	"	One gr.

Koreshan Astronomy. Under this title in the September *Budget* (California) will be found one of the most remarkable articles of the present decade. If the writer has survived that effort he surely will never fossilize in this geological stratum of human knowledge. He is embryonic of something to come, nobody can imagine what.

COMET NOTES.

Ephemeris of Comet c 1890 (Denning July 23). From Dr. Krueger's elements as given in *A. N.* Vol. 125, p. 219, I have computed the following ephemeris.

Although this comet will be so low and faint by Nov. 1, that it probably will be practically out of reach of northern observatories, yet, as it is possible that it may be seen in the southern hemisphere, I subjoin the following ephemeris.

If we assume its light on Oct. 1 as unity, its light on Nov. 1 will be 0.50 and on Nov. 30, 0.28.

Ephemeris of Comet c, 1890 (Denning July 23.)

Gr. M. T.	App. R. A. h m s	App. Dec. ° ′	Log. r.	Log. Δ.
Nov. 1.5	16 38 22	− 34 11	0.1414	0.3165
2.5	39 34	34 43		
3.5	40 47	35 14		
4.5	42 1	35 46		
5.5	43 16	36 16	0.1494	0.3282
6.5	44 32	36 46		
7.5	45 48	37 16		
8.5	47 5	37 46		
9.5	48 24	38 15	0.1579	0.3391
10.5	49 42	38 44		
11.5	51 2	39 12		
12.5	52 24	39 41		
13.5	53 44	40 9	0.1667	0.3491
14.5	55 7	40 37		
15.5	56 30	41 4		
16.5	57 54	41 32		
17.5	16 59 18	41 59	0.1758	0.3583
18.5	17 0 45	42 26		
19.5	2 12	42 52		
20.5	3 39	43 19		
21.5	5 8	43 45	0.1851	0.3667
22.5	6 38	44 11		
23.5	8 10	44 37		
24.5	9 41	45 2		
25.5	11 14	45 28	0.1946	0.3743
26.5	12 49	45 53		
27.5	14 25	46 18		
28.5	16 1	46 44		
29.5	17 38	47 8	0.2042	0.3813
30.5	17 19 16	− 47 33		

O. C. WENDELL.

Harvard College Observatory, Oct. 11, 1890.

Comet of Barnard (October 6.) The faint comet discovered by Barnard on October 6, is undoubtedly that of D'Arrest. A hasty comparison of his position with that of an ephemeris, published by Leveau in *Comptes Rendus*, Tome CX, No. 3. page 121, gives for a correction to the computed place $\Delta\alpha = - 6^{m}.6$; $\Delta\delta = - 1'$. Cloudy and rainy weather has prevented us from getting any observations at the Naval Observatory.

E. FRISBY.

The Re-discovery of D'Arrest's Comet. On Oct. 6, I discovered a large faint comet in Sagittarius with the 12-inch equatorial. From the first three observations Mr. Schaeberle computed a preliminary orbit. Upon comparing this orbit with those of the catalogues it was at once seen that the object was the long searched for D'Arrest's comet which had been given up as lost, so far at least, as this return was concerned. The re-discovery of this comet was purely in the line of original search, as the search for D'Arrest's had been given up as hopeless, like that of Brorsen's. The identity with D'Arrest's comet was not even suspected until its orbit was computed. The accidental discovery of this comet after such a thorough and exhaustive search for it, and long after it had passed its most favorable position, brings up an important question as to the condition of its light for the past six months. It has become very much brighter since my first observation on Oct. 6, and an object one-tenth as bright could be easily observed. The position of the comet was on Oct. 15, $7^h\ 7^m\ 15^s$ Mt. Hamilton M. T.

α app. $19^h\ 49^m\ 52^s.9$ δ app. $27°\ 33'\ 19''$

which gives the correction $-\ 0^m.5 - 3'$ to M. Leveau's ephemeris in *A. N.* 2959. E. E. BARNARD, Mt. Hamilton, Oct. 16, 1890.

Comet 1890 II (Brooks, March 16). This comet may be seen in the morning about two hours before sunrise. The following ephemeris is taken from *Astr. Nach.* No. 2995.

1890	α app.	δ app.	log r	log Δ	H
Nov. 5	$13^h\ 11^m\ 0^s$	$+26°\ 3'.0$	0.4288	0.5118	0.42
7	11 12	25 58.9			
9	11 21	25 55.5	0.4340	0.5100	0.42
11	11 28	25 52.9			
13	11 33	25 51.1	0.4391	0.5078	0.41
15	11 35	25 50.1			
17	11 34	25 49.8	0.4442	0.5051	0.41
19	11 30	25 50.3			
21	11 22	25 51.6	0.4493	0.5019	0.40
23	11 11	25 53.7			
25	10 56	25 56.6	0.4544	0.4983	0.40
27	10 38	26 0.3			
29	10 16	26 4.8	0.4594	0.4943	0.40
Dec. 1	9 50	26 10.1			
3	9 19	26 16.2	0.4644	0.4899	0.40
5	8 43	26 23.1			
7	8 2	26 30.8	0.4694	0.4825	0.40
9	7 16	26 39.3			
11	6 25	26 48.6	0.4744	0.4803	0.40
13	5 29	26 58.7			
15	13 4 27	+27 9.7	0.4793	0.4751	0.40

Stenwarte Wien-Währing 1890 Sept. 22. *Friedrich Bidschof.*

Comet 1889 II (Barnard). Professor E. Millosevich, at the Observatory at Rome, has computed the elements of the orbit of this comet, using all the published observations from March 31 to Nov. 21, 1889, and finds the eccentricity to be very nearly unity. He finds that these elements satisfy very closely the observation by Mr. Barnard August 23, 1890, when the comet had reached a distance of 5.054 times the earth's distance

from the sun and 4.063 from the earth. The elements referred to the plane of the equator are.

$$\begin{aligned} T &= 1889 \text{ June } 10.8098285 \text{ Berlin M. T.} \\ \left.\begin{aligned} \pi' &= 11^\circ\ 34'\ 04.42'' \\ \Omega' &= 224\ \ 21\ \ 06.95 \\ i' &= 162\ \ 26\ \ 12.74 \end{aligned}\right\} & \text{Equator 1889.0} \\ \log q &= 0.3532083 \qquad q = 2.25532 \\ e &= 0.9995208 \end{aligned}$$

NOTES AND NEWS.

One of the rough discs from Jena for the new 16-inch telescope for Carleton College Observatory has been received by Mr. Brashear, of Allegheny. It is now being tested by himself and Dr. Hastings of Yale University.

From a recent private letter we learn that Professor C. A. Young, of Princeton is to have a new powerful spectroscope, and Mr. Brashear of Allegheny is given the contract for its construction.

Lawrence University Observatory. We are pleased to know that Lawrence University, Appleton, Wisconsin, is to have a new Astronomical Observatory. In November, 1889, Professor Underwood of that institution undertook the work of securing such an equipment, consisting of the following instruments: A 10-inch Clark equatorial, 4-inch transit circle, sidereal clock, a mean time clock, chronograph and spectroscope. The business men of Appleton have given the building, and the Methodist people of the state are putting in the instruments. The Observatory will be ready for use, as now planned, in September, 1891. Professor Underwood is to be congratulated.

Memoirs of the Royal Astronomical Society. Part II, Vol. 49 (1887-89) of the Memoirs of the Royal Astronomical Society is received. This part contains four papers: 1. A discussion of Greenwich observations of north polar distance with reference to the position of the Ecliptic and an annual variation of the value of co-latitude, by W. G. Thackery. 2. On the belts and markings of Jupiter, by N. E. Green, with four full page plates in color. 3. The total eclipse of the sun, 1887, Aug. 19, by Professor J. Arai, Director of the Tokio Observatory, Japan, with one plate, and four Photographs and drawings of the sun by Rev. S. J. Perry, D. Sc., F. R. S., with three full page plates.

We have from time to time made full reference to most of these important papers while presenting the subjects to which they refer in recent numbers of the MESSENGER, the last two especially. The plates are beautifully executed, and contain an amount of detail shown only in the best work of the kind. At the close of this part is found a complete list of persons to whom the medals or testmonials of the society have been adjudged. The list contains the names of 78 persons, the first award of the gold medal being made June 13, 1823, to Charles Babbage, Esq., for his invention of

an engine for computing and printing mathematical tables, and the last was adjudged to M. Maurice Lœwy, for his equatorial Coudé, his method of determining the constant of aberration and his other astronomical researches.

Variation of Latitude. It seems to be well settled (see *A. N.* No. 2993) that the latitude of places varies from time to time, by small amounts, perhaps not exceeding half a second. While the great argument for such changes, the supposed diminution of the latitude of Greenwich by a whole second or more since 1750, has been entirely confuted by Auwers' new reduction of Bradley, it is now known that the latitude of four or five stations in Germany has varied somewhat irregularly, as it seems, from season to season, of the same year, 1889. The investigation was begun on the testimony of Küstner's observation of 1884-5.

The article just quoted confirms the original observations by Pulcova determinations of the same year. The Pulcova series was made with the great vertical circle of Ertel, which has been re-divided by the Repsolds; and the probable error of one observation of the Polar star (really, I believe, four complete observations are made every time) is $\pm 0''.136$; so that it has been quite possible, by a comparison of ten such "observations" in the fall of 1884, with 34½ smaller ones in the spring of 1885, to deduce a diminution of latitude equal to $-0''.33 \pm 0''.05$. Dr. Küstner himself had determined at Berlin a similar diminution equal to $-0''.49 \pm 0.03$, but with an additional probable error of nearly $0''.1$ owing to doubts concerning the constancy of observations; as he employed a great "universal transit" used as a zenith telescope.

Certain practical considerations may be added. The Pulcova vertical circle is an instrument (like a great theodolite or alt-azimuth) in which the zero-points are determined by level-readings; and the "universal transit," with an aperture of 4.6 English inches has a prism in the cube, and the eye-piece in the axis. So that the prejudices which some American observers cherish against the level and the "broken telescope," as means of the most exact observation are quite groundless, and disappear entirely when the instruments in question are rightly made and properly handled.

But the time is quite gone by when rough instrument making can be tolerated, T. H. S.

The Great Forty-Inch Lens. In a recent number of the Boston *Herald*, is found an interesting account of an exhibit of the great forty-inch lens, by the Clarkes, of Cambridgeport, Mass. This is one of a pair of lenses intended for the great telescope to be placed on Wilson's Peak of the Sierra Madre range of mountains, distant from Los Angeles about twelve or fifteen miles, and which will form the objective of the new equatorial that will be the principal instrument of a new Observatory for the University of Southern California. This large lens was exhibited to a party of friends a few weeks ago, an account of which has already appeared in several eastern papers, and hence, only a few facts about the lens will be given at this time.

The diameter of the glass is said to be forty inches, two and one-half

inches thick at the center and one and one-half inches at the edge. Its value as a rough disc is not given. It is said to be insured for large sums of money in two of the leading companies of Boston. When both lenses of the objective are completed and in the cell, this part of the great telescope will probably cost about $65,000. In the article above referred to, it is said that the Clarkes are uncertain yet whether they will grind the discs at their shop in Cambridgeport, Mass., or build new shops near Mount Wilson and do this part of the work there. It is mentioned that the transportation alone of the Lick object glass cost $3,000. This course may be pursued to avoid expense and additional risk in transportation. This new telescope is to have a photographic lens, in all probability, though that point, as far as we know, is not yet part of the contract. If this telescope shall be completed, as indicated in this report and others previously made, the diameter of its object-glass will be four inches greater than that of the Lick telescope, and it will have a focal length somewhere between 56 and 60 feet, exactly how long, the Clarkes will not know till the lenses are finished. The focal length of the Lick telescope is 57 feet. The observatory floor of the Lick is 4,209 feet above sea level. The height of Wilson's peak is said to be 6,000 feet above sea level. It is also claimed by the friends of the new Observatory, that its site offers superior advantages to those of Mount Hamilton on account of frequent fogs that roll in from the Golden Gate. How this is we do not know, but it would seem, from a casual view of the shape of Wilson's Peak, that much and great unsteadiness of air might be expected at either day or night. We sincerely hope that we are wrong in this anticipation, for if true, it would prove a terrible drawback to continuous work, or excellent work even of discontinuous kind.

Publications of the Leander McCormick Observatory. Volume I part 4 of the Publications of the Leander McCormick Observatory, University of Virginia, is devoted to double-stars. The working list of stars included all known pairs between 30° and 0° of declination which were less than 4″ of distance apart, and several very close and difficult pairs north of the equator which for special reasons needed observation. The observers were F. P. Leavenworth and Frank Muller. The 26-inch equatorial was used with eye-pieces ranging from 200 to 2,000. It is noticed that in nearly all the observations, a right-angled prism was placed before the eye-piece by revolving which the double-stars could be made to assume any apparent position-angle desired. In getting position-angles the stars were made to bisect the space between two close wires, first with a forward and then with a backward rotation of the micrometer-box, the observer being careful that the apparent position-angle was zero at the moment of observation. For distance between components the usual method of measure was employed.

The observer in double-star work will find this catalogue a useful one both in regard to matter and method.

On the Law of Attraction of the Stellar Systems is the title of a paper by T. J. J. See, a student in astronomy at the Royal Frederick William University of Berlin, Germany. This paper proposes a method by which the

spectroscope may be applied rigorously to test the universality of the law of Newton. We have not the space to present the steps of the argument of this interesting paper, we can only give the results in brief, as derived by the author, an American student of prominence in higher mathematical researches.

The conclusion from an astronomical point of view, is, that it is impossible to conclude, from a rigorous example, that the law of Newton presides over the movements of the double-stars, although this is very probable. Professor Hall's view on this point is quoted in the following words: "Since we can only observe the following orbits (double-stars) and the fact that they describe equal areas in equal times, we may conclude that the force is central, but we cannot determine the law of this force as in the case of planetary motions. The difficulty arises from the fact that the focus of the real orbit is not generally projected upon the focus of the apparent orbit in which we observe the equal description of areas. Our inference of Newton's law must be from analogy." Professor Hall further says: "The theoretical difficulty in proving the law of Newton for the double-stars can not be overcome. But we may increase the probability of the existence of this law, by determining more orbits and those differently situated. If the law proves satisfactory in all cases, we shall have a probability of its universality increasing with the progress of astronomy."

The author of this paper after fairly stating this difficulty in the case of known methods of proof, proceeds to develop his method, which calls for the use of the spectroscope, which he claims, proves the point that is declared impossible of proof.

His first point is that the motion in double-star orbits is planar. Although there are many laws under which a body may describe a conic, of all these the Newtonian is the only one which has the star in the focus.

"To ascertain whether the star systems obey the law of 'inverse squares,' it is only necessary to determine the inclination of the orbit upon the line of sight, for this will enable us to decide whether the star is in the real focus of the ellipse," and the spectroscope is the instrument adapted to this kind of observation, consequently the author claims that method (the details of which are not here given) is established as generally a competent one.

The Relations of Men of Science to the General Public, was the title of the address of T. C. Mendenhall, as retiring president of the American Association of the Advancement of Science, at its annual meeting in Indianapolis for the year 1890. The main points of his theme were:

1. The particulars in which scientific men fail, as exponents of science among their fellows. Under this head is named with proper qualification, the fact that such men are sometimes unable, or unwilling, to present the results of their labors in form intelligible to intelligent people.

2. Men of science are liable to fall into the error of assuming superior wisdom as regards subjects outside the lines of their specialties.

3. Men of science are not always reasonably free from egotism in matters relating to their specialties, particularly in reference to authority and attainments in the same.

4. Another element of weakness in scientific men, is that they are often less "practical" in their work than they should be. Sometimes they even despise the useful and practical in science, and their dignity is disturbed when an honest and innocent layman asks what the use of this or that discovery is. This we deem one of the most important points of the address, because the fault is so commonly noticed and spoken of by intelligent laymen. We have ourselves been recently ashamed of some of our prominent scientific men for grevious errors in this way.

5. The last point of the paper is the demand which the public may justly make upon the man of science, that his interest shall not be less in public affairs than that of other men. The paper as a whole, is well calculated to call the attention of scientific men generally to a line of usefulness and an opportunity for good not duly appreciated heretofore.

Photographic Notes. "Professor Pickering, basing his conclusions on a series of photographs of the planet Mars, concludes that the southern temperate regions of Mars have just experienced an irruption of Polar ice."—*Photographic Times.*

Mrs. M. Fleming is constantly increasing the number of known variable stars through the careful examination of the Harvard College stellar photographs.

"Dr. J. C. Kapteyn, in the course of his measurements of the photographic plates taken at the Cape Observatory, has looked carefully for any difference of photographic magnitude of the same star on different plates, which might indicate variability, with the surprising result that up to the present he has found nine cases of possible variability—in one of which the body is already a known variable. . . . It is interesting to compare this result with that announced by Mr. Roberts to the Royal Society on 1890, Jan. 23, when he considered that at least ten stars in a single photograph showed signs of variability. The cases are not strictly parallel, for Mr. Roberts deals with much fainter stars, and those in a position of the heavens which is to some extent *sui generis*, viz: the neighborhood of the Orion nebula."—*The Observatory.*

Mr. William Huggins and Mrs. Huggins have recently published two papers of photographic interest. These papers are, Note on the Photographic Spectrum of the Great Nebula in Orion and On a New Group of Lines in the Photographic Spectrum of Sirius.

Rigel and the Great Nebula. Students in astronomy were startled with the announcement, not long ago, that probably nearly the whole constellation of Orion, would prove to be parts of one immense whirlpool nebula, having the great nebula of the sword as the most prominent center of condensation. In an article written by Miss A. M. Clerke, the leader of the October *Observatory*, several facts of interest concerning the relative positions of the stars and the nebulæ are grouped together, some of which are the following:

1. It is certain that stars and nebulæ co-exist in sidereal space, but by no means is it certain that they co-exist indiscriminately everywhere.

2. All nebulæ with which exact astronomical acquaintance has yet

been made are sensibly immobile, unless indeed those attached to the stars of the Pleiades rank as an exception, and (it ought to be said in addition) the few nebulæ which have been observed for motions in line of sight.

3. The nebular relationship of the star Rigel in the constellation of Orion is quite conclusive, as determined by the studies of Father Secchi, Dr. Scheiner's photographic researches; Herschel suspected it. Dr. Gill's parallax offers favorable suggestions, Dr. Auwers' studies, also of proper motions, while Vogel's spectroscopic determinations and Pickering's photographic work all offer useful contibutions to the great nebulous system of Orion.

4. What is the motion of this great system if anything like uniform motion exists there? The spectroscope must be appealed to for a careful and thorough examination of the parts of the system, and it seems that definite and prompt answer may be given by the aid of this instrument.

Dark Transit of Jupiter's Third Satellite. September 2d, 7^h 43^m, 90th M. T. I turned my 5-inch telescope with power of 120 upon Jupiter and saw what appeared to be the shadow of a satellite on the lower belt and near the center of the disc of the planet, and on referring to the ephemeris I found it to occupy the position of satellite No. 3. A steady look showed it to be a jet black dot which I was unable to distinguish by appearance from a shadow. On applying the 200 power E. P. fifteen minutes later the image appeared elongated transversely with the belts (north and south).

I observed it closely during the remainder of transit, could detect no change during the entire time until within eight minutes of egress when the inky black became less intense. On the satellite's emerging and with the dark sky background, it appeared with its usual brightness.

Definition fairly good.

Lat. + 38° 29′, Long. 85° 45′.

Charlestown, Ind. WILLIS L. BARNES,

Recent Longitude Determinations. During the past few months the longitudes of the following points have been determined by the telegraph method by the U. S. Coast and Geodetic Survey:

Helena, Montana.
Bismarck, Dakota.
Minneapolis, Minn.

Salt Lake City, previously determined, was used as a base.

The following additional points are now being determined from Washington, D. C., as a base:

Augusta, Georgia.
Gainesville, Florida.
Jacksonville, Texas.

Assistant C. H. Sinclair of this service, was in charge of the party executing both series of determinations. T. C. M.

Publications of Washburn Observatory. Parts I and II of Volume VI have been received. Part I consists of observations with the Meridian Circle by Alice Maxwell Lamb and Milton Updegraff, assistants

in the Observatory, of a list of over fifty stars. Individual observations are given for both co-ordinates. The purposes for which this list was observed were: (1) For use in determining the latitude of Washburn Observatory by the zenith telescope; (2) Observations of comparison stars of planet 181 *Eucharis*; (3) Observations of stars of a refraction list, and (4) Observations of zero stars from the Berlin Jahrbuch.

The second part consists of observations of double-stars by George C. Comstock, Director of the Observatory. In the introduction to this part will be found a full discussion of points of interest pertaining to the 15½-inch equatorial by Clark, the methods of observation, and the star places of certain star catalogues under consideration. This catalogue of double-star measures covers ninety pages in which individual observations of distance and angle are given, each having an average of about four observations.

Polaris and Companion. In accordance with the suggestion of the MESSENGER to amateurs to keep watch of the companion to Polaris, I have made a few observations during the past week, which clearly seem to indicate a very perceptible change in brightness, as compared with neighboring stars. The comparison stars used are shown on the following diagram. The stars *a* and *b* are on the Durchmusterung of Argelander. The telescope employed is a 3¼ inch achromatic. Powers used were 50 and 100.

My notes show as follows (the compa nion being indicated by v):

	h	m	
October 10	8	42	*a o v*
October 12	9	03	*a 2 v 1 b*
October 18	8	30	*b 2 v 1 c*

As I have been engaged in variable star observatious for the past six years, and have been in the habit of estimating in tenths of magnitudes, I do not think that the above differences can be entirely due to the errors of observations, but, of course, many more observations will be necessary, in order fully to establish the supposed variability.

Madison, N. J., 14 Oct., 1890. JOHN H. EADIE.

Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac. Part V of Vol. II is a discussion of observations of the Transit of Venus in 1761 and 1769, by Simon Newcomb. The second chapter gives the observations of the transit of Venus, June 5–6, 1761, following the order of Encke's list of stations and references, as given in the opening part of each of his works. The third chapter presents the observations of the transits of Venus, June 3, 1869, as obtained from the same sources and a few others named. The fourth chapter discusses the geographical positions of the stations, the fifth, tabular elements to be cor-

rected by observation; the sixth, tabular summary of observations and their comparison with the tabular times; seventh for formation and solution of the equations of condition, and the eighth, discussion of result. The final result reached for the equatorial horizontal parallax is 8″.79 ± 0″.051 or ± 0″.034; the first error being mean, and the second probable.

This discussion also brings out a correction to LeVerrier's latitude of Venus at descending node for mean of 1761 and 1769 of + 1″.915 and a correction to LeVerrier's longitude of node for 1765.5 of + 32″.4.

The first chapter of this paper is a general introduction, in which its author notices the changes of opinion on the value of observations made on the transits of Venus in 1761 and 1769, and probably the wrong tendency to adopt the values of astronomical constants obtained during the last century instead of results obtained by a judiciously weighted mean of all previous determinations. The solar parallax affords a case in point. In 1854 Hansen's value by the parallactic equation of the moon made Encke's value of the parallax decidedly too small. But Hansen's definitive determinations in 1862-63 were 8″.916 and Foucault's from the velocity of light was 8″.86, while that by Stone and Winnecke was respectively 8″.943 and 8″.964. The result of these investigations was to reject Encke's result entirely, whereas, if all these results and others known had been judiciously combined, such a weighted mean would have been, as we now know, much nearer the true value. For, Professor Newcomb says, it would have changed the final result of his own discussion in 1867 to a value probably somewhere between 8″.79 and 8″.82. There are several other interesting points in this discussion that deserve notice in this connection but space at present forbids.

Orbit of Delta Cygni as computed by J. E. Gore gives the following elements.

$P = 376.659$ years	$\Omega = 98° \ 40'$
$T = 1914.16$	$\lambda = 175° \ 7'$
$e = 0.327$	$a = 2''.39$
$i = 41° \ 26'$	$\mu = -0.9957$

The computed position-angles compare well with the observed ones since 1783.

President Lewis McLouth, of the South Dakota Agricultural College, has decided to build a small Observatory for that institution. He is now in correspondence concerning the instruments.

Professor Bacon, of Smith Observatory, Beloit College, has been granted a short leave of absence on account of ill health.

The Photographic Chart of the Sky. The fifth part of the Bulletin of the Permanent International Committee has just come to hand. From the announcement of the President of the Committee, Admiral Mouchez, we learn that 10,000 francs have been donated by M. Bischoffsheim, for the construction of apparatus for measuring the photographic plates. The next meeting of the committee is called for March 31, 1891, at the Observ-

atory of Paris. Most of the Observatories are ready to begin work, and the work will be begun immediately after the meeting of the committee in March, 1891. The Bulletin contains papers by Messrs. Holden, Schaeberle, Lindemann, Common, Turner, Christie, Trepied and Pickering, and correspondence between different members of the committee.

Of late we have had a number of inquiries for small second-hand telescopes. Those wishing to sell good instruments with apertures from three to six inches are requested to inform us of the fact, and we will be glad to name the persons desiring such instruments.

Publications of the Astronomical Society of the Pacific. Number 10 of Volume II comes to hand just as we go to press with the last form of this issue. The articles of this number are, "Drawings of the Moon," by Professor Weinek, "The Age of Periodic Comets," by Daniel Kirkwood, "Notes on Astronomy in South America;" "Corrigenda to v. Oppolzer's Lehrbuch zur Bahnbestimmung der Kometen und Planeten;" "A Suggestion of a Way to Forward our Knowledge of the Asteroids;" "On Photographs of the Milky Way made at the Lick Observatory in 1889, pp E. E. Barnard. Under the head of Notices from the Lick Observatory the following appear:

That the rotation time of Venus is thought to be, by the observations of Schiaparelli, 224.7 days, the same as its time of revolution around the sun.

That some rather singular black spots are observed just within the north edge of the north equatorial band of Jupiter. These were exactly like the shadows of the satellites for which they were first mistaken. One of them is situated near the red spot.

That an interesting phenomena of bright spots projecting beyond the terminator of Mars was observed by the aid of the 36-inch refractor on the night of July 5 and 6.

That a black transit of the IV satellite of Jupiter was observed Aug. 13, 1890, at the Lick Observatory, by the aid of the 12-inch equatorial by E. E. Barnard and J. M. Schaeberle. It appeared black and perfectly round. It was some distance preceding two of the singular small black spots on the north edge of the equatorial belt, and about in the same latitude. The surface of Jupiter rotating faster than the apparent motion of the satellite caused the small black spots to overtake it, and the preceding of the two was seen to catch up with, and pass behind, the satellite, and finally to emerge on the preceding side of it. When about three-quarters across the disc of Jupiter the satellite had a slightly brownish tinge (reddish black), but later this slight tinge of red disappeared, and the satellite was of a cold black color. The most singular view was near the end of the transit. It became smaller as it approached the limb, and seemed extended slightly north and south. It did not appear to lose its blackness as much as it did its size. Finally it was a very small black speck, and not yet in contact with the limb. A little later a small portion of its disc was seen protruding beyond the edge of the planet, and when nearly half off this portion did not appear round, but wedge-shaped. As the satellite emerged that part remaining on continued black, while the portion off the disc was as bright

as the adjacent part of the planet. The dark part seemed to be left behind, and to shrink into smaller and smaller space on the disc of the satellite as it emerged, until the blackness entirely disappeared. When fully off the disc of Jupiter, the satellite appeared small, and of a uniform pale ashy tint. As compared with Satellite I, which was near it and preeeding, it was not over one-fourth as large as that satellite in diameter, and many times less bright.

In another note Professor Holden offers the suggestion that the parallax of nebulæ may possibly be studied successfully by the aid of photography. The suggestion is, by suitable device the exposure time may be so reduced, that the nebula may be made to give an image upon whieh perfectly precise measures of position can be made. Now if a series of such negatives made with exactly the same exposure times, were continued throughout the year, it is believed they would afford suitable data for the determination of parallax.

We are glad to notice that the Lick Observatory has recently become the recipient of a gift of an electric lighting plant by the Edison General Electric Company, of Orange, New Jersey. That generous gift was presented September 4, and consists of a complete plant of steam engine and boiler, dynamo, belting, main wire, controlling wire and a set of storage cells in duplicate—the whole as a free gift.

BOOK NOTICES.

The Elements of Plane and Solid Geometry, with Numerous Examples. By Edward A. Bowser, LL. D. Professor of Mathematics and Engineering in Rutgers College, New York. D. Van Nostrand Company, Publishers, 23 Murray and 27 Warren Streets. 1890, pp. 393.

In writing this book the author has aimed to combine the excellencies of Euclid with those of the best known modern writers, retaining the syllogistic form of demonstration, but re-arranging the order of matter somewhat, and making such changes in the demonstrations as seemed to him to be either necessary or desirable. Teachers of experience know that Euclid's treatment of the angle is deficient, and that his arrangement of propositions is poor because of a lack of systematic classification of themes that the logic of mathematical thinking ought to bring out. It is in this line, perhaps, more than any other, that modern books on geometry are improvements on the work of the renowned old Greek geometer; and this work is a contribution in the same direction. In Book one of the Plane Geometry the first proposition is, "All straight angles are equal to one another." At first reading such a proposition seems novel, and scarcely necessary to the completeness or integrity of the course desired, and yet under preceding definition it is admissible.

The form of demonstration employed is brief and compact by the free use of symbols, and the exercises that follow the themes, and the notes that are frequently interspersed, are desirable features in this text-book. The matter is about the same as that which will be found in most of the good text-books on the same subject. The whole subject is divided into nine books, the Plane Geometry being treated of in the first five instead of six as is the common way.

Father Perry, F. R. S., The Jesuit Astronomer. A Sketch of his Life, Work and Death by Aloysius L. Cortie, S. J. London. The Catholic Truth Society, Publishers, 21 Westminister Bridge Road, S. E., pp. 113. Price One Shilling.

It will be remembered that this journal gave a full page frontispiece plate of the late Father Perry in its May issue which also contained a brief biographical sketch of his life,

In the neat little book before us a much fuller account of his life, work and death is to be found, with illustrations of such phases and incidents of his work as would naturally interest the reader. A good half-tone plate of Father Perry is made the frontispiece, then follow pictures of Stonyhurst College, the Observatory, the telescopes used for solar work, enlarged sunspots, maps showing the places visited by Father Perry in his scientific journeys, lakes to the south of Observatory Bay, a group of natives of the S. W. of Madagascar, the "Coronagraph" at Sault, with Father Perry, Capt. Atkinson and Lieut. Thierens in the last expedition, and a full page view of the corona of sun as photographed by Father Perry, Dec. 22, 1889. This little volume is a full, appropriate and an unpretentious statement o[f] the leading facts of a very worthy life. It is a book for the genreral libary.

The Pathway of the Spirit. A Guide to Inspiration, Illumination and Divine Realization on Earth, by John Hamlin Dewey, M. D. New York: Publishers, Frank F. Lovell & Co., 142 and 144 Worth Street. pp. 300. Cloth, gilt, $1.25.

This book is the second by the same author in a series called "Christian Theosophy Series," the first being "The Way, the Truth and the Life." In presenting the theme, "The Pathway of the Spirit," the author divides it nto two parts: (1) Immediate inspiration and knowledge of God, the supreme necessity and universal possibility of man. (2) Inspiration and divine illumination: their special nature and distinguishing characteristics. To establish the first point the author shows the necessity of God-knowledge; that moral sense is rooted in divinity and is not expediency, that man must have direct intercourse with God, that the Kingdom of God is the Kingdom of truth and righteousness, and that truth pertains to a knowledge of all things, and of our relations to them, spiritual and physical; and that righteousness is the right use of this knowledge and of our powers in its pursuit, and that the throne of power and government is within and yet above the soul; that Adam and Christ are representative types of character and both possible to man, Adam presenting the natural man subject to temptations of the sensuous life, and Christ the spiritual man in unity with the father, and that the best in both are possible to man in this life, on earth, if he will overcome on the one side, and win and possess that which is offered and within reach on the other. In speaking of "the fall," we notice that the author treats the Garden of Eden as a story for the illustration of truth, and not as a historical fact, and that under the head of "Revelation opens equally to all," he holds that authority is not in the book we call the Bible, though it contains never so much of truth in external statement, but in the unwritten word of God, in the soul that recognizes and receives it." That probably means that the author does not believe in plenary inspiration. Professedly the author is not a materialist

nor a pantheist. He is a theist and a believer in Christ. Under the paragraph entitled, "The Key to Missionary Success," the statement is made that "the appeal must be made directly to the authority and word of God in each soul," and that, in using the scripture, the lives of inspired men and the words of inspired men recorded in all true scripture, should be pointed to for example, instruction and encouragement in the way of life, not as arbitrary authority.

As a whole, the first part of this book is a discriminating and generally a careful statement of the leading facts about immediate inspiration and knowledge of God, and the supreme necessity and universal possibility of man in a general sense, but little, scarcely anything, is said about sin and its direful consequences. The motive of love in this higher life is, of course, the greater one, but the dreadful fact of the ruin of sin in this world is left wholly out of sight as a motive, or a factor in operation. The Bible is very explicit on this point as well as the other.

When we come to carefully read the second part of this book concerning the nature and distinguishing characteristics of inspiration and divine illumination, we find considerable food for thought. What is said of mind cure, physical healing, Christian science, white magic, etc., is doubtless true but we are not sure that evil is but the perversion of good, and therefore has a beginning and an end. Nor do we believe that because "love and goodness" exist, universal redemption is assured; nor that "Our Father in Heaven," in the Lord's Prayer, is thought of by the lost now, or ever will be, as a meaningless "character." Does not the truth rather lie in the fact that the lost will call on the rocks to fall on them and hide them from the wrath of the Lamb. The Devil is not the dark shadow of the Lord's glorious presence, neither is the cry of Dives for mercy an unfinished prayer rarified to infinitesimal tenuity by the possibilities of a second probation. It also seems that the author's ideas of evolution are of such a harmless kind that they do not give much complexion really to his belief in and statements of the new theology to differentiate it from the old doctrine. Of course nothing is longer said by the new school people, on spontaneous generation, nor very much about the origin of species. The searching tests of the truth in the last few years are reducing these theories to proper level and expunging all mischievous errors. We do not undervalue this book by these references. It has much truth in it, and an inspiration for the reader that he will probably never forget. The stimulus is worthy and wholesome and its spirit is progressive and uplifting.

Imperial Observatory at Rio Janeiro, Brazil. Tome IV, parts 1 and 2 of the *Annes do Imperial Observatorio do Rio de Janeiro* have been received. The first part is a neatly printed quarto volume of 123 pages, containing an extended introductory paper on the distribution of the group of planetoids between Mars and Jupiter. This paper is by E. Liais and L. Cruls and is accompanied by a full page plate, showing, in colors, groups of orbits of nodal points. Then follows a discussion of the observations of the transit of Mercury on May 6, 1878, the transit of Venus, 6 Dec., 1882, and a list of measures of double stars. The second part is devoted to meteorological records from 1883 to 1885 inclusive, and is a large volume of 406 pages.